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Evaluation of a Recirculating Sand Filter Followed by a Subsurface-Flow Constructed Wetland to Achieve Denitrification

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NATIONAL SMALL FLOWS CLEARINGHOUSE

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With more than 250 million tires discarded annually (approximately one tire per person), and that number showing no signs of declining, the scrap-tire market continues to search for new uses for old tires. One growing market for recycled tires is the onsite wastewater treatment industry, which uses them for aggregate in soil absorption systems. Just one manufacturer in Georgia, for instance, processes more than 10 million tires per year, and approximately two-thirds of these chips are used as onsite system aggregate.

Using tire chips as aggregate for conventional septic systems has been approved by a number of states, including South Carolina, New Mexico, Iowa, Virginia, and Arkansas. "I think others should give this a look," said Carl Graves, environmental health specialist, Arkansas Department of Health, Little Rock, Arkansas. "It really surprises me the number of waste tires you can use in a standard absorption system. An average system with five, 60-foot lines, for example, would use approximately 1,400 to 1,500 used tires. As an environmentalist, I think using that many tires for just one system is a good deal."

Scrap Tire Laws

Historically, waste tires took up space in landfills or became breeding grounds for mosquitoes and rodents when stockpiled or illegally dumped. This changed in 1985 when Minnesota enacted the first state law for managing scrap tires. Since 1985, all but two states, Alaska and Delaware, have enacted a similar state law. The three areas that states have generally focused on are program management for scrap tires, creation of market development programs, and stockpile abatement. According to the Rubber Manufacturers Association, 38 states ban whole tires from landfills, 35 states allow shredded tires to be placed in landfills, 11 states ban all scrap tires from landfills, 17 states allow processed tires to be placed into monofills, and 8 states have no landfill restrictions.

Waste Tire Markets

Markets exist for more than 75 percent of the nation's waste tires, according to South Carolina's 2001 *Waste Tire Management Report*. Some of these markets include tire-derived fuel, playground cover, running surfaces, soil amendments, flooring and matting, roofing shingles, road-fill applications, and rubber-modified asphalt.

Tire Chip Performance Research

Research has proven tire chips are a viable alternative to gravel. (See "Analysis of Tire Chips as a Substitute for Stone Aggregate in Nitrification Trenches of Onsite Septic Systems: Status and Notes on the Comparative Macrobiology of Tire Chip Versus Stone Aggregate Trenches," in this issue of *Small Flows Quarterly*, page 18.)

Systems that fail using tire chips as aggregate would be treated the same as systems that fail using gravel as aggregate. "I sincerely doubt it would be a fire threat to leave tire chips in the drainfield of a failed system as long as

the shreds do not exceed 10 feet deep. Typically, tire chips in a drain medium are no more than 3 feet deep, and that's just not enough to build up a critical mass of heat to cause a fire," said Michael Blumenthal, senior technical director, Rubber Manufacturers Association, Washington, D.C.

Cost Considerations

Sources indicate that aggregate costs can be reduced by 10 to 90 percent when tire shreds are used in place of gravel. Savings depend upon a number of variables, including how plentiful gravel is, distributor's selling price, and freight costs (both distance and weight; a cubic yard of gravel weighs about 2,800 pounds, as compared with a cubic yard of tire chips, which weighs only 800 pounds).

"We use a ton of gravel for every seven feet of trench. A ton of tire chips goes 21 feet," said Bob Ardoyno, tire chip distributor and septic system installer in Waycross, Georgia. "In a job that is 3 lines, 70 feet long, I'd use one truck load of tire chips. If I used gravel, I'd need two truckloads. It costs me more travel time, more fuel costs, more wear and tear on my truck (a job requiring 75 tons of gravel can be done with 25 tons of tire chips), and more money for aggregate," said Ardoyno. "My profits doubled when I made the switch."

Increased profit is one reason Ardoyno expanded his system installation business to include distributing tire chips. "One of my customers spent $150,000 for gravel, money for a driver to haul it 125 miles, and purchased a big truck to carry the load. After I explained how he could reduce costs while increasing profit by using tire chips, he sold the truck, dropped the driver, and increased his profit by more than $75,000 doing the same amount of work he had done the previous year. But even stories such as his don't impress some people. Some of our 'mom and pop' corporations have been burned trying new things in the past, so they like sticking to the old way," Ardoyno said.

Tire chips increase the drainfield storage capacity by 30 percent because the void space between tire chips (62 percent) is greater than the void space for gravel (44 percent). Drainfield size is unaffected.

End-User Rebate Programs

Some states have end-user rebate programs, including processors in Louisiana and Oklahoma, and end-users in Utah, Virginia, Colorado, Iowa, and Nebraska. Virginia's end-user rebate program began in 1997, and, according to Allan Lassiter, manager of Virginia's waste tire management program for the Department of Environmental Quality, Richmond, Virginia, they have no plans to stop it.

"The way the program works in Virginia is that the end user is reimbursed up to $22.50 a ton for tires originating from a tire retailer and $100 a ton for tires recovered from a certified stockpile in the state," Lassiter said. "We track it through a certificate that the retailer issues to the hauler at the time the waste tires are picked up. The certificate has four duplicate pages. The top sheet has a signature line for the tire retailer, tire hauler, tire collector, and tire processor. As the certificate moves from retailer to processor, each signs the top sheet and retains a duplicate copy of the certificate.

"After the certificate has all the necessary signatures, the installer submits the form to the Department of Environmental Quality and is reimbursed for the cash value of the certificate. Sometimes, installers share the money with the processors and the homeowners.

"We even pay installers from other states, as long as they use Virginia tires. North Carolina, for instance, processes a substantial number of our tires," Lassiter said, "and if an installer from another state buys our tires from them, we'll cut a check for them, too."

Iowa Experiments with Tire Chips in Sand Filters and Constructed Wetlands

Brent Parker, senior environmental engineer, Department of Natural Resources, with the state of Iowa, awarded money from his waste management account to Appanoose, Davis, Lucas, and Monroe (ADLM) Counties so that they could put in some experimental systems using tire chips as aggregate. "ADLM has soil with a high clay content (Armstrong, Shelby, Garra, and Edina), so instead of soil absorption trenches, they use sand filters. Tire chips replaced rock in the distribution and collection areas. They also used tire chips in constructed wetlands," Parker said.

Bill Milani, a sanitarian in ADLM, used tire chips in 24 systems, a combination of sand filters and constructed wetlands. "We started using tire chips in 1999, but we've only completed one year of our two-year continuous water sampling tests because of construction delays. In another year, we'll have conclusive results about the systems' performance. So far, tire chips are working well in the subsurface sand filters," Milani said.

"Because of freight costs, it wasn't as cost-effective as we had hoped. River rock in this part of Iowa is inexpensive and plentiful ($9 a ton, washed). On the other hand, because tire chips are so light, you get a lot more for your dollar than you do with river rock.

"As construction grows and river rock supplies decrease, it might make sense to use tire chips more frequently. There are some changes I'd make,

A subsurface-flow constructed wetland cell in Iowa uses tire chips as aggregate. Photo by Bill Milani.

though. I'd want debeaded tire chips (wires completely removed). Although more costly, it would eliminate the aesthetic problem iron deposits create at the end of the cells—red water. It would also eliminate the safety problem (slicing the handler) wires cause. Another change I'd make is to screen the pipes to prevent chips (1.5 to 2 inches) from floating into them, clogging the pipes," Milani said.

Milani filled the 18-inch-deep constructed wetlands with 12 inches of tire chips and 6 inches of gravel. Layering the tire chips with gravel served two purposes: it ensured the tire chips wouldn't be moved about by the wind, and it helped plants root better.

While Milani said tire chips were easy to rake, he pointed out they were bouncy, making it difficult to walk on them. He also noticed some settling after a year.

South Carolina First State to Use Tire Chips as Aggregate

Tire chips are frequently used in southern states because soil is sandy, and rock quarries are nonexistent. The idea for using tire chips in South Carolina originated from a conversation between Clifton Roberts, public health official, Horton County, South Carolina, and a manufacturer in the northern part of the county. This manufacturer used the sidewalls of truck tires to produce pivot wheels for rotary mowing machines called bushhogs. (A rotary mower is an instrument used to chop down bushes and undergrowth.) He took the remaining pieces of sidewall and stacked them together with long, threaded rods, making them into drain tile. He chipped the rest of the rubber for aggregate in drainage ditches and French drains. Wondering if it would work for soil absorption systems, he asked Roberts to test it.

Armed with a five-gallon bucket of tire chips, Roberts and Steve Baxley, county supervisor, Conway, South Carolina, tested its storage capacity and found it had more void space than rock. Roberts took the idea to the health department in Columbia, and they agreed to use tire chips as aggregate in soil absorption systems on an experimental basis. After monitoring the systems and seeing no problems with surfacing or malfunctioning, South Carolina approved using tire chips as aggregate.

South Carolina has used tire chips as aggregate in septic drainfields since 1993, and contractors and health officials are satisfied with the results. "Over the last 5 years, we have installed approximately 5,048 septic systems, 98 percent of which have tire chips for aggregate," said Baxley. Horry County alone uses more than one million tires per year as aggregate for drainfields.

The demand for tire chips has grown quicker than the number of processors, making tire chips a scarce commodity in South Carolina. "Most of the chippers we use are in North Carolina, and since North Carolina just approved the use of tire chips this year, their tire chip market has exploded," Baxley said.

Arkansas

Four years ago, the Arkansas Department of Environment Quality urged the Department of Health to consider approving scrap tire chips for use as aggregate in soil absorption systems. "We had lots of questions about how well they would perform and if they would cause a public health problem," Graves said. "After considerable research, we felt it was worth trying. We modeled our guidelines after Virginia's and South Carolina's."

Arkansas has not experienced any problems with properly installed systems using tire chips as aggregate, but they have experienced some problems with operators and installers. For example, laborers for one operator weren't careful using the backhoe and scooped up too much dirt with the chips. This dirt ended up in the absorption field, clogging it. A local environmental specialist worked with the operator to correct the problem. Another problem Arkansas experienced was holes in backhoe tires from the two-inch metal rods that came from chipped truck tires. They've eliminated that problem by switching to chipped car tires that don't have the metal rods. Sometimes too much metal was attached to the chips because processors didn't keep the teeth on their shredders sharpened.

"Some installers have commented that they feel more confident on steep sites with a backhoe bucket of tire chips than they do with a bucket of gravel, because tire chips are so much lighter. They also see much more aggregate for their dollar with tire chips. We have had a number of installers quit using tire chips, though, because they found them difficult to spread when they put them in the trench and tried to level them," said Graves.

Ardoyno cautions against dismissing tire chips as an alternative too quickly. "The chips do have spring to them, but once you get used to them, you should find them easier to work with and faster to use than gravel because they weigh two-thirds less. They are also much easier on your equipment," said Ardoyno. Both Graves and Ardoyno warn that wire rods protruding from tire chips could cause a flat tire on a backhoe if you don't fill your tires with sealant that immediately seals tire punctures.

New Mexico

Two years ago, Steve Walker, program manager in the New Mexico Environment Department, agreed to permit five systems using tire chips on an experimental basis after he was approached by a newly-formed tire processing company. After observing the first system, which was installed at the tire-processing site, Walker noted several problems. First, wire protruded from some of the chips in such excess that they resembled spider webs, literally slicing those who handled the chips. Second, the processed tire chunks were small and flat. "They resembled a stack of Pringles™. There was very little space between them," said Walker. "The processor operated on a tight budget, and I don't think his shredder functioned properly. Some of the tires were cut, and some were ripped apart, and the chips the shredder produced from car tires were too small for aggregate. Tires from large earthmovers produced nice sized chunks, but they were rare to find because the tires can be retreaded."

Before Walker could document the system and monitor its performance, the tire processing plant burned down and was never reestablished, leaving the remaining four permitted systems undone. "If using tire chips as aggregate was proposed to me again, I would try it, but I would be more discerning about the shape and size of the chip and the amount of wire left in," said Walker. "Having the right shredder is critical. Right now, the tire chip business in our area is dead for lack of a manufacturer."

Quality Control

"When I first started distributing tire chips, I told the processor our business relationship wasn't going to work without strict quality control," Ardoyno said. "I can't ship junk to people. It would never pass the health department's inspection. I turned down five loads recently when the processor brought in a new manager. It took a lot of work to get it right, but now the quality is good," Ardoyno said.

When Ardoyno sells tire chips to installers for the first time, he prefers to go on a job with them and show them the best way to work with them. "In small rural towns, your name can become pretty mucked up if you don't do things right," Ardoyno said. "For example, you might have some people down at the local coffee shop talking about their installation, saying tire chips were left all over their property. Now what's a property owner going to do with a half ton of tire chips. The wires from the chips could slice their foot open if they aren't wearing heavy shoes.

"I can't have that happen. If installers don't want to do it right, I won't sell to them."

Ardoyno points out that tire chips need to be covered with a geotextile material rather than the treated paper used to cover gravel because the wire would rip the paper, allowing dirt to get into the trenches.

Everyone Wins

Using tire chips as aggregate for drainfields is a great way to recycle tires. It saves the homeowner money and increases the installer's profit.

Because rock quarries are commonplace in Alabama, the cost difference between tire chips and gravel is negligible. In a recent presentation to public officials and wastewater professionals in Alabama, Ardoyno explained that using tire chips as aggregate would completely eradicate Alabama's waste tire problem. "The number of onsite septic systems installed in 1998 in Alabama was 26,500 with an average drainfield linear footage of 275, or 825 square feet. The average number of rubber tires used in an average drainfield was 1,100. This means that one ton of rubber tire chips will provide 10 inches of aggregate for a drainfield that is approximately 26 linear feet long and 36 inches wide. Based on the average drainfield size, 4,600 septic tanks would totally eliminate the 5,048,600 tires discarded in Alabama in 1999," said Ardoyno.

Future of Tire Chips as Aggregate

Most installers that have used tire chips say they wouldn't go back to traditional materials. There are a number of reasons why tire shreds are becoming widely accepted by the septic system construction industry.

Tire chips contain 62 percent void space, as compared to 44 percent with stone. This allows tire chips to hold more water than stone. Tire chips are lighter than stone, making it easier to work with the tire chips, cutting installation time in half and enabling installers to put in twice as many units a day. Freight costs are drastically reduced because of the variance in weight between tire chips and gravel. Tire chips are less expensive than stone, sometimes even hundreds of dollars less, and in some states, installers are awarded with a rebate for using tire chips. Tire chips do not significantly compact, therefore 12 inches of tire chips is equivalent to 12 inches of washed gravel. Stories about compaction are few and involve sandy soil. Using tire chips helps the environment by eliminating the need to excavate natural rock and provides an alternative to tire disposal.

Using tire chips as aggregate in onsite systems has gained favor in many parts of the country. While tire chips have been proven to be a viable alternative to gravel, expanding their use throughout the country will be based on approval from appropriate state agencies and economics. In areas of the country where tire chips are less expensive than stone and where state regulations do not restrict this application, it is expected that this market will expand.

For more information contact Graves, Arkansas DOH, (501) 661-2584; Blumenthal, Rubber Manufacturers Association, (202) 682-4800; Ardoyno, Bob's Septic Tank Company, (912) 283-6727; Lassiter, Virginia's DEQ, (804) 698-4215; Parker, Iowa's Dept. of Natural Resources, (515) 725-0337; Milani, Iowa (641) 437-1909; and Baxley, South Carolina DOH and Environmental Control (843) 248-1506.

Top: Bottom layer of trench with 6 inches of chips and 4-inch pipe. Middle: Pipe covered with 2 inches of chips Bottom: Tire chips covered with geotextile material. Job ready for inspection by health department. Photos courtesy of Bob's Septic Tank Company, Waycross, Georgia.

Analysis of Tire Chips as a Substitute for Stone Aggregate in Nitrification Trenches of Onsite Septic Systems:

Status and Notes on the Comparative Macrobiology of Tire Chip Versus Stone Aggregate Trenches

By Barbara Hartley Grimes, Ph.D., Steve Steinbeck, P.G., and Aziz Amoozegar, Ph.D.

Note: This white paper has been reviewed by North Carolina's OnSite Wastewater Section—Department of Environmental Health (DEH-OSWS) and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of DEH-OSWS. The mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

It is estimated that at least 250 million tires (about one tire per person) are discarded annually in the United States (21). This high number of used tires presents a significant problem for disposal and has led to intense research and development for reusing and recycling tires. In a two-year period (1999 and 2000), counties in North Carolina reported receiving 9.5 million tires (136,536 tons in monolandfills) (10). Because of the high volume of waste tires, problems associated with their disposal, aesthetic problems, and the expansion and innovation of reuse of used tire products is being addressed aggressively. Chipped or shredded tires are being used for a wide variety of products, including playground covers, doormats, roadbed, fill, shoes, and aggregate substitute in septic system drainfields. This paper will describe and analyze the current available information on the use of tire chips as a substitute for stone aggregate in septic system drainfields.

In more than 17 states, tire chips/shreds are currently permitted for use or are under experimental evaluation as an aggregate substitute for stone aggregate in septic system drainfields. Some of the scrap tires in North Carolina are being chipped and exported to

A tire chip processor in action in Cameron, North Carolina. Photo courtesy of Tim Warren.

South Carolina for use in septic systems. Tire chips have recently been approved as an aggregate for septic systems in North Carolina. (See Approval: **www.deh.enr.state.nc.us/oww**).

The number of discarded tires used in onsite systems can be significant. For example, approximately 2.3 million passenger tire equivalents in Georgia, 300 tons of tire chips in Iowa, 100 million tires in Florida, and about 30 percent of used tires in Oklahoma are being used in septic systems.

Specifications and Definitions: General Description of Tire Chips

Tires can be cut into small pieces called *tire chips* or *tire shreds* by various techniques. The New York State Roundtable defines chips as *"A classified scrap tire . . . which is generally two inches (50.8mm) or smaller and has most of the wire removed ..."* and shreds as *"Pieces of scrap tires that . . . are generally between 50mm (1.97") and 305 mm (12.02") in size"*(11). The physical characteristics of the tire chips, such as size, wire protrusion, and fines are controllable factors in the processing of tire chips. Based on this, the term tire "chips" is more suitable as a substitute for stone aggregate than the term tire "shreds."

According to the Texas Natural Resource Council Commission (TNRCC), while passenger tires may vary in size and shape, they have similar general physical and chemical characteristics and are composed approximately of 85 percent carbon, 10 to 15 percent ferric material, and 0.9 to 1.25 percent sulfur (20). (More specific information on rubber, metals, and other compounds in tires can be found in Appendix I.) For example, studies have shown that new versus used tire chips have similar performance when used as aggregate in septic systems (18).

The relatively stable structure of tire chips makes them a suitable substitute for stone aggregate in the septic system. In addition, tire chips are three times lighter than stone aggregate (e.g., a cubic yard of stone aggregate is 2,800 pounds and a cubic yard of tire shreds is 800 pounds). Also, in many cases, tire chips have shown to be one-third the cost of stone aggregate for use in septic systems (18).

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 (approx 2 inches), with wire protrusion of 0.5 inches or less. These regulations also require a "no fines limit" and geotextile fabric to cover the tire chips before ground covering. This is a general overview, and examples of specific regulations in some southeastern states can be found in Appendix II.

Top: Tire chips before installation. Bottom: Tire chips excavated from system eight years later shows growth of biofilm and lack of tire chip decomposition. Photos courtesy of Barbara Grimes.

The major differences in state regulations are in the percent of tire chips meeting specification required (80 percent, 90 percent, etc.) and the oversight, inspection and /or certification of the tire chip specifications (Appendix II). Few states address the bead wires, cleanup, and any limits on depth to groundwater, other than standard installation requirements.

Main Issues in Tire Chip Substitution (Demonstration/Experimental Projects)

Concerns for tire chip use include storage, handling of chips with protruding wires, post-installation cleanup of stray tire chips, potential for compression or compaction, and durability of the chips. In storage, the accumulation of dirt and stray materials needs to be prevented. Persons handling the chips should use care, wear thick gloves and appropriate clothing (including thick-soled shoes), and have current tetanus protection. Cleanup must be addressed in the post-installation inspection.

Research has shown that compaction is not a significant problem, and our inspection of tire chips in the trenches of a number of 8-year-old drainfields in South Carolina revealed that the tire chips were not degraded or damaged by wear. These demonstrate the durability of tire chips in septic system drainfields. Recommendations have been made from several research/demonstrations projects that tire chips should be firmly compacted prior to covering with geotextile fabric.

One field survey conducted in South Carolina did not show a significant number of failures in tire chip systems that were greater than 10 years old or evidence of settling problems over the drainfields. Porosity was found to be higher with tire chips than stone (60 percent for tire chips; 40 percent for stone) (13, 16–18).

Sewage Distribution, Performance, and Biomat Formation

Performance studies comparing stone aggregate drainlines and tire chip aggregate drainlines in various combinations of alternating drainfields and alternating drainlines show in all cases equivalent or similar wastewater dispersal to the soils within the trenches filled with stone aggregate and tire chips drainfields (2,13,16–18). Permeability of tire chips was found to be equal to that of stone aggregate. In some cases, less ponding was recorded in the tire chip systems than systems that were constructed using stone aggregate (13,16–18).

Waste treatment efficiency in all studies using tire chips was equivalent to that achieved in stone aggregate drainfields. Wastewater treatment testing in more than one project examined BOD_5, COD, TSS, ammonia-nitrogen, nitrate, fecal coliforms, and pH, and showed equivalent treatment, except that the wastewater treatment efficiency in tire chip trenches sometimes took several months to reach the same rates. Conductivity profiles demonstrated little precipitation in either type of aggregate (13,16–18).

Biomat formation and macrobiology of tire chips in comparison to stone aggregate systems examined in North Carolina and South Carolina (Appendix III) demonstrated a thicker biomat and a surprising level of supported invertebrates in the tire chip trenches. Only nematodes were found in a two-year-old system in North Carolina. demonstrating an aerated system that allows them to provide an additional treatment of waste constituents.

In the South Carolina systems (older than 8 years), we found more trophic levels (feeding types) of micro- and macro-organisms, which indicated a stable ecological wastewater treatment community (1, 5, 14, 15, 22). The organisms included grazers, saprophytic feeders, and filter feeders. This complexity and diversity of organisms demonstrates the potential for additional levels of wastewater treatment in tire chip aggregate, keeps the biomat pores open, promotes healthy biomat regrowth by grazing, and indicates a healthy and diverse ecosystem in the tire chip trenches (1, 5, 14, 15, 22).

In comparison, only a few protozoa were found in a stone aggregate system in South Carolina. Evaluation of both stone aggregate and tire chip systems that were overloaded (i.e. high level of ponding) showed that the healthy ecosystem was not present in tire chip trenches when overloaded.

A Question of Leachates

Major in-depth studies of leachate from tire chip versus stone aggregate drainfields, include: Amoozegar and Robarg, 1999 (2) in North Carolina; Burnell and Omber, 1997 (3); Envirologic, 1990 (6); Liu. Mead, and Stacer, 1998 (8); Robinson, 2000 (13); Sengupta and Miller, 1999 and 2000 (16, 17); and Spagnoli, Weber, and Zicari, 2001 (18).

One of the major questions raised in using tire chips as a substitution for stone aggregate is the potential leaching of various constituents from the tire chips. Bench studies and field testing have examined tire chip leachate under normal and "worst case scenario" conditions (2, 3, 6, 8, 13, 16, 17, 18). The pollutants of interest in these studies indicate that volatile and semi-volatile compounds do not enter the leachate. Other studies have demonstrated that ground rubber and tire chips actually remove some of the organic compounds from fluids percolating through them (7, 18).

Studies under typical septic system conditions have shown that tire chip leachate and stone aggregate leachate contain high concentrations of iron (16, 17). The levels of iron, which is a secondary drinking water contaminant (aesthetic), however, does not seem to pose a health problem. The studies at the Chelsea Center showed that tire chips were actually a sink for iron when compared to the influent concentration (16, 17).

This demonstration installation of tire chips in a septic system in North Carolina featured the use of a steel brace for supporting the distribution pipe while the chips were loaded into the trench. Photo courtesy of Tim Warren.

In some studies, manganese (secondary drinking water standards) was higher in the tire chip leachate than in the aggregate leachate (18). In the Chelsea Center studies, on the other hand, manganese concentration was mostly constant in the effluent in the D-box, but was of equivalent concentrations in stone aggregate and tire chips in the trenches although fluctuating in both—being sometimes higher in the aggregate and sometimes higher in the tire chips (16, 17).

In the Chelsea studies, zinc leachate was lower than secondary drinking water standards; in both trench types, zinc concentrations were lower than in the distribution box while paralleling D-box fluctuations (17).

As for the effluent macrobiology in the trenches, it appears that the iron in the presence of some unknown factor(s) in tire chips enhances macrobiological growth. Accumulation of harmful trace metals does not appear to occur as evident by the biological growth in the South Carolina systems.

Overall, it appears that tire chip substitution for stone aggregate is an excellent alternative for onsite systems in regard to wastewater treatment, durability, and economics. Using tire chip aggregate in septic systems also provides a viable solution to recycling used tire waste. As a result of the data, a 1:1 substitution was recommended and approved for use in North Carolina. Because of the biological studies (and other researchers' recommendation (18) and, we do not recommend tire chips be used for areas with seasonal high water tables, using less than one foot separation for Group 1 (sand, loamy sand) (1.5 feet in sandy soils), or conditions (e.g., undersizing) that result in overloading the drainfields. Additionally, physical hazards, worker safety, and compliance with the specifications must be addressed.

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APPENDIX I

General Tire Composition
(Modified 1999 TNRCC Fact Sheet):

Weight: Passenger Tire 18.7–20.0 pounds
Truck tire about 100 pounds

Volume:

Number of Tires Needed for One cubic yard:

Car Tires	10
Truck Tires	3
Shredded car tires (1 pass)	33
Shredded truck tires (1 pass)	7
Shredded car tires (2 inch chips)	47

Basic Ingredients:

Fabric: Steel, nylon, aramid fiber, rayon, fiberglass, or polyester (usually a combination)
Rubber: Natural and synthetic (hundreds of polymer types)
Reinforcing chemicals: Carbon black, silica, resins
Anti-degradants: Antioxidants/ozonants, paraffin waxes
Adhesion Promoters: Cobalt salts, brass on wire, resins on fabrics
Curatives: Cure accelerators, activators, sulfur
Processing aids: Oils, tackifiers, peptizers, softeners

Composition of One Popular All-Season Passenger Tire:

Weight : 21 pounds

Composition:

30 different synthetic rubbers	5 lbs
8 types of natural rubber	4 lbs
8 types of carbon black	5 lbs
steel cord for belts	1 lb
polyester and nylon	1 lb
steel bead wire	< 1 lb
40 chemicals, waxes, oils, etc	3 lbs

Approximate composition Percentages:
85% carbon
10-15% ferric material
0.9-1.25% sulfur

Typical Percentages of Rubber Mix in Some Types of Tires:

	Synthetic Rubber	Natural Rubber
Passenger tire	55%	45%
Light Truck Tire	50%	50%

TRNCC Information :

Using Tire Shreds in Onsite Sewage Facilities (Septic Systems)
Shreds are three times lighter than stone aggregate:
Cubic yard of stone aggregate: 2,800 pounds
Cubic yard of tire shreds: 800 pounds

TIRE CHIP AGGREGATE SUBSTITUTION FOR GRAVEL IN ONSITE SYSTEMS:

Examples of Southeastern State Rules

STATE	TERM USED: Chips or Shreds	Bead Wire	Fines	Dimensions	Wire Protrusions	Percent Compliance	Geotextile Fabric	Meeting Specifications	Other Requirements	Other Restrictions	Processors Approval	Approval Continued
GEORGIA F-19: Tire chip approval when installed on conventional septic tank system criteria and absorption field methods	Tire Chips	X	The aggregate must be free of balls of wire and fine rubber particles. The chips must be clean and free of any soil particles either adhering to the chips or floating loose within the chips.	The size of the tire chip aggregate shall be one-half to two inches in diameter	The percentage of tire chip aggregate with greater than one-half inch exposed wire shall not exceed ten percent	The percentage of tire chip aggregate with greater than one-half inch exposed wire shall not exceed ten percent	The absorption line with tire chip aggregate must be covered with an approved geotextile fabric or silk screen prior to back filling	The minimum depth of aggregate shall be twelve inches with six inches below				
SOUTH CAROLINA Revised, 1995	Tire Chips	X	Fines are prohibited	Chips may not be smaller than one-half inch or larger than four inches in size	Wire strands may not protrude more than one-half inch from the sides of the chips	At least 90% of the chips must meet the technical specifications	Absorption trenches must be covered with geotextile (synthetic) fabric prior to backfilling	Tire recyclers may, at their option, submit chip samples to the Division for evaluation. The results will not constitute a general or blanket approval for any producer. The actual, final approval of tire chips occur at each septic system job site				
VIRGINIA Revised 1997	Tire Chips	X	DEQ < 2mm are prohibited	DEQ Nominal two (2) inches in size may range from 1/2 inch to a maximum of four (4) inches in any one direction	DEQ Exposed wire may protrude no more than one-half inch from the chip	DEQ At least 95% of the aggregate by weight shall comply with specifications routinely, Processors inspected regularly. Semi annual contractors	Department of Health Regulation Application Untreated building paper or geotextile (synthetic) fabric cover shall be used to cover the tire chips before backfilling	Each installation must have a valid VDH permit ; must be authorized by the property owner and certified by VDH and the installation contractor using the 4 part VDH-DEQ Certification of Use of Tire Chips in a Res-idential Septic Drainfield				
NORTH CAROLINA NEWLY APPROVED OCT. 2002	Tire Chips	X	Shall be clean and free (98% or better by weight) of any soil particles (fines) either adhering to the chips or floating loose within the chips;	1. Shall be nominally two (2) inches in size and may range from _ inch to a maximum of four (4) inches in any one direction (95% or better by weight); 2. Shall be graded or sized in accordance with size numbers 2, 3, and 24 of ASTM D-448 (standard sizes of coarse aggregate)	Shall not contain wire protruding more than one-half inch from the sides of the chips (95% or better by weight); and	OSWS At least 95% of the aggregate by weight shall comply with the sizing standards;Tire processors must be approved by OSWS yearly	The tire chip aggregate shall be covered with a single and continuous layer of non-woven filter fabric extending across the top of the tire chip aggregate before backfilling. The fabric shall have a unit weight of at least 3.0 oz./yd2 (per ASTM D-5261), a permittivity of at least 1.0 sec-1 (per ASTM D-4491), a trapezoid tear strength of at least 35 lbs. (per ASTM D-4533), and have a mesh size equal to U.S. Sieve No. 70 (A.O.S.)(ASTM D-4751).	Tire chip aggregate for subsurface sewage effluent absorption systems shipped from approved tire processors shall be accompanied by a freight bill of lading labeled as drainfield aggregate . The bill-of-lading shall certify that the material meets the specifications for drainfield use. Contractors purchasing tire chip coarse aggregate shall retain a copy of the freight bill-of-lading as documentation of the tire chip aggregate size and quality. A copy of the bill of lading shall be provided to the local health department prior to issuance of the operation permit, and shall be retained with the operation permit filed with the local health department.	"1. All tire chips not used in the nitrification trench shall be removed from the site by the installer or contractor for the onsite wastewater system. 2. No soil shall contaminate the tire chips during installation.	1. For LPP systems, the orifices shall be protected from aggregate shadowing by sleeving the discharge pipe laterals within the perforated pipe [which meets Rule .1955(e)] typically used for conventional nitrification lines. 2. The minimum vertical separation required by Rule 15A NCAC 18A .1955(m) shall not be reduced, notwithstanding the use of any advanced wastewater treatment system.	1. Any tire processor wishing to provide tire chip aggregate for use in onsite sewage treatment and disposal system drainfields in the state of North Carolina shall receive written approval from DENR-DEH-OSWS. Tire Processors must provide proof that they can continuously produce a tire chip coarse aggregate in conformance with the specifications in II of this approval ; Tire processors shall submit a representative sample of tire chips to DEH OSWS ; The processor shall have samples analyzed by a third party laboratory qualified to conduct particle size analysis for compliance with the above specifications ;	Documentation of tire processors' product meeting the above specifications, shall be submitted as requested, at least yearly, to OSWS ; Noncompliance with this approval may subject a tire processor to suspension or revocation of their approval

FLORIDA (tire chip only)	**Rules:** Tire chip coarse aggreg. (Or tire aggreg.)	At least 80% of the bead wire must be removed from the tires to be chipped	NA	Gradations shall conform to the following requirements*	Exposed wire may protrude no more than one-half (1/2) inch from 90% of the chips	In addition to gradation requirements not more than 3.75% by weight of the aggregate material at the point of use shall pass through a #200 sieve	No specs for geotextile fabric	county health department / inspection	domestic strength waste only; tire chip aggregate systems shall be limited to new or repaired domestic onsite systems, and those in which the bottom surface of the drainfield is at least 12 inches above the water table at the wettest season of the year	***Manufacturer Approval & Labeling (A)*** Any manufacturer wishing to provide tire chips for use in onsite sewage treatment and disposal system drainfields in the state of Florida must first receive a letter of approval from the State Department of Health, Bureau of water and OnSite Sewage Programs. Manufacturers must provide proof that they can produce a tire chip coarse aggregate in conformance with the standards in Section I, Physical properties	***Manufacturer Approval & labeling (B)*** Tire chip aggregate from approved manufacturers shall be labeled as a drainfield aggregate on the freight bill-of-lading The bill-of-lading shall clearly certify that the material meets the requirements for drainfield use. Contractors purchasing tire chip coarse aggregate shall retain a copy of the freight bill-of-lading as documentation of the aggregate size and quality. Contractors shall retain bill-of-lading records and shall make them available for department review for a period of two years from the date of purchase.
FLORIDA (tire chip and mineral aggregate mix)	Use of mixed tire and mineral aggregate is approved	—	—	—	—	—	—	county health department / inspection			
	*Sieve Size	2in	1 1/2 in	1 in	3/4 in	1/2 in	3/8 in	no. 4 (4.75mm)			
	Percent passing	90-100	35-100	15-100	0-70	0-50	0-30	0-5			

APPENDIX III

Macrobiology

Macrobiology Methodology: 2–8 years post-installation: hand digging in trenches; Evian water to wash out organisms from biomat. Dissecting microscope used to examine the biomat and tire chips. Identification to taxonomic class.

NC Experimental wastewater system (1): NC rules of conventional installation. (Approval online OSWS) Dr. Aziz Amoozegar Soil Science NCSU System with alternating stone aggregate trenches and tire chip trenches. Results of sampling the biomat for protozoa and metazoa (higher forms)

Excavation

Tire chips: well-structured "honeycomb" does not collapse on excavation
Stone aggregate: no structure; collapses on excavation

Appearance of Aggregate

Tire chips: intact, good separations, covered in a "fuzzy beige biofilm," wires oxidized and mostly gone.

Stone aggregate: fairly clean—no attached biofilm

Biomat Underneath The Aggregate

Tire chip trenches: well-formed biomat trench bottom—black
Stone aggregate trenches: well-formed biomat—dark

Macrobiology

Tire chip trenches: No protozoa; nematodes in abundance
Stone aggregate trenches: No protozoa or nematodes

South Carolina Septic Systems (6) —installed SC rules: Drain line directly on soil, then aggregate, covered geotextile fabric. Tire chip systems are widely used in Horry County, S.C. Sampled near Conway, S.C.—Mobile Home Park with both types of systems and soils—at least 8 years old. Results of sampling the biomats for protozoa and metazoa (higher forms)(as always, other factors involved—heavy rains days before our trip)

Excavation

Tire chips: well-structured "honeycomb" does not collapse on excavation. After 8 years drainfield was not collapsed—well structured

Stone aggregate: no structure ; collapses on excavation

Appearance of Aggregate

Tire chips: intact, not pitted, covered in a "fuzzy beige biofilm," wires oxidized, almost gone.

Stone aggregate: fairly clean—no attached biofilm

Biomat Underneath The Aggregate

Tire chip trenches: well-formed biomat trench bottom—thick (several mm) black sheet of biofilm; somewhat intact

Stone aggregate trenches: well-formed biomat—very thin (mm) dark beige/black

Macrobiology

Tire chip systems sampled

I. Systems with effluent in trenches—no protozoa or metazoa
II. Normal System—abundant forms
  a. Protozoa—3 types of ciliates
  b. Metazoa—oligochaetes (aquatic /segmented worms) (3 types at least – maybe some parts...)
  c. Metazoa—nematoda (roundworms) somewhat abundant
  d. Metazoa—insect larva (psychodidae—filter fly/ drain fly)

Stone aggregate systems

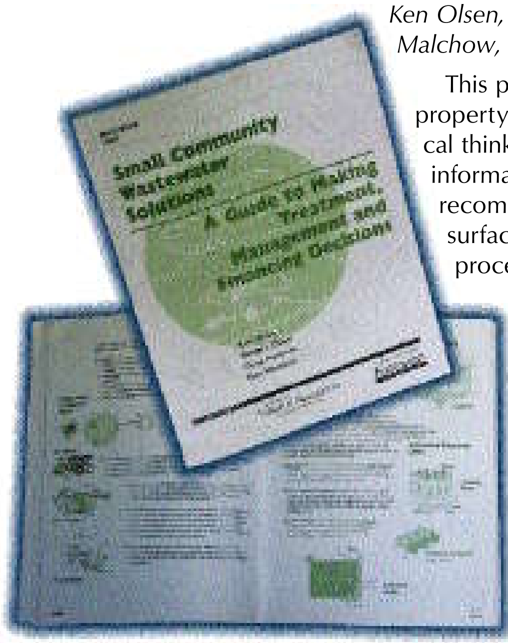
I. Normal trenches—no protozoa or metazoa or small protozoa later in cultures
II. System with effluent in trenches—no protozoa or metazoa

New NSFC Products Are Available

Please note that shipping charges apply to all orders, even if the product itself is free.

Small Community Wastewater Solutions: A Guide to Making Treatment, Management, and Financing Decisions

Ken Olsen, Bridget Chard, Doug Malchow, and Don Hickman



This publication aims to help property owners become critical thinkers with respect to the information, concerns, and recommendations that will surface as they begin the process of solving their wastewater problems. It also provides the tools small communities need to access this data and to make independent, informed judgments and choices. The first chapter offers a quick grounding in wastewater problems; followed by a chapter-by-chapter roadmap to small community wastewater treatment solutions. It explains what the people in a community will need to do, including what they need to know before making any decisions, sewage treatment system options, wastewater management options, community organizational structure options, financing wastewater systems, working with professionals, and finally, implementation of the plan. There is a glossary and several appendices that include sample surveys, a summary of treatment options, scientific abbreviations and measurements, and a guide to common acronyms. The book is a comprehensive guide to making community wastewater treatment decisions. Local officials and other community leaders will find it particularly useful, and it is a good resource for researchers and the general public, planners, managers, state officials, public health officials, and finance officers.

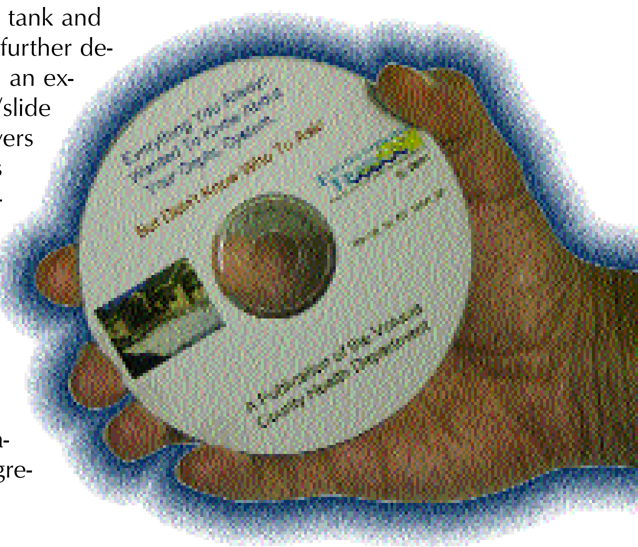
The cost of this book is $19.50. Request item #FMBKGN210.

Everything You Always Wanted To Know About Septic Systems…But Didn't Know Who To Ask! Homeowner Version 1.0

Environmental Health, Volusia County Health Department

This interactive CD ROM educates homeowners about conventional onsite systems. The CD is divided into six main sections, including

- the history of the modern septic system,
- public health issues,
- effluent characteristics,
- failures and repairs,
- frequently asked questions, and
- Web sites for additional information.



The septic tank and drainfield are further detailed through an extensive video/slide show that covers such topics as septic tank requirements, use of dosing tanks, types of tanks to use, aerobic treatment units, drainfield location, what aggregate and lateral pipe to use, and alternative soil absorption systems. Although some sections are based upon Florida regulations, this CD can be edited to reflect regulations and requirements specific to any state or local jurisdiction. This CD ROM may interest those who work with or are in contact with homeowners, such as public health officials, regulators, contractors, and developers, as well as the general public.

The cost of this CD is $6.50. Request item #WWCDPE76.

A Status of Tools and Support for Community Decentralized Wastewater Solutions

National Decentralized Water Resources Capacity Development Project

This report is the result of two 2002 workshops (organized by the Green Mountain Institute for Environmental Democracy and supported by the National Decentralized Water Resources Capacity Development Project). The purpose of the workshops

was to better understand the services and tools available to communities and how these tools and services can be improved. Experts in the application of decentralized solutions met with representatives of community projects that had already decided or were in the process of deciding on wastewater solutions. This report tries to identify situations where additional effort can strengthen the participation of communities in making wastewater decisions that apply managed decentralized solutions, when appropriate.

The two workshops focused on distinct aspects of decentralized wastewater system development. The first workshop emphasized the issue of interactions between community representatives and technical experts, such as wastewater engineers. The second workshop covered the relationship between a community and state agencies that are required to regulate wastewater and often provide assistance. Both workshops were designed to recognize the role of service providers in assisting communities.

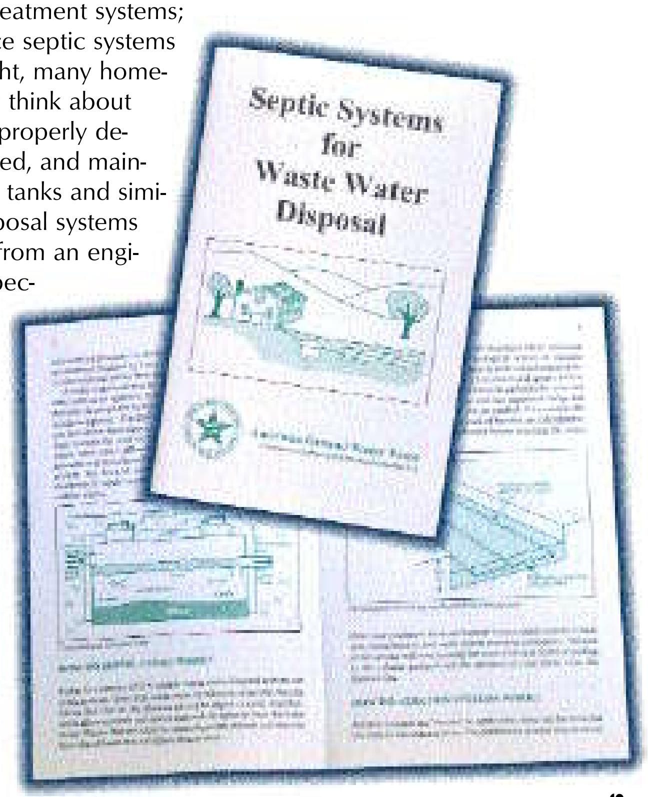
The first part of this report is structured to run through each of the steps in the community process that leads to the choice and implementation of wastewater solutions. These steps constitute a "community process." From the observations noted, the remainder of the report identifies key findings that provide the basis for the last section of conclusions. This information will be useful to local officials, the general public, planners, managers, state officials, state regulatory agencies, and engineers.

The CD is free. Request item #WWBKMG21.

Septic Systems for Wastewater Disposal

American Ground Water Trust

One-third of all American homes use onsite wastewater treatment systems; however, since septic systems are out of sight, many homeowners rarely think about them. When properly designed, installed, and maintained, septic tanks and similar onsite disposal systems are effective from an engineering perspective, economic for the homeowners, and friendly to the environment. All states have septic system regulations that are intended to protect groundwater. Most onsite wastewater systems are used for homes that also have their drinking water supplied by a well. In some rural and suburban areas, sewer lines have to stretch great distances to connect homes with a centralized treatment plant, making the connection to such systems impractical. Fortunately, in many rural areas, natural soils can treat wastewater as thoroughly and safely (using an onsite disposal system) as municipal sewage treatment systems. This booklet provides basic septic system information for homeowners. It discusses several topics, including the purpose of wastewater disposal systems; how septic tanks and aeration systems work and when to use them; the purpose of a soil absorption system, how it works, and siting requirements;



how to prevent system failure; and where to go for additional information. This booklet will be useful to public health officials, contractors/developers, and the general public.

The cost of this booklet is 65 cents. Request item #WWBLPE75.

State Onsite Wastewater Regulators and Captains of Industry Conferences: Interactive CD ROM

National Small Flows Clearinghouse

This interactive CD-ROM documents the proceedings of the 2002 State Onsite Wastewater Regulators and Captains of Industry Conferences held in Newport, RI, in March 2002. From each of the conference agendas, several full-text papers and/or presentations as well as opening remarks can be viewed on screen or downloaded and printed. Topics include the status of onsite systems, pathogen and nutrient treatment and transport in soils, an overview of Capacity Development work, cluster systems, onsite wastewater planning and zoning, a model onsite system ordinance project, and U.S. EPA onsite wastewater initiatives. The CD also includes a photo gallery, lists of attendees and presenters with their contact information, and additional resources, along with a follow-up article from the *Small Flows Quarterly.* The CD-ROM will be of particular interest to those wastewater professionals involved with onsite wastewater regulations, including government officials with regulatory oversight, local officials, public health officials, engineers, manufacturers, and consultants. To access the files on this CD, you will need the following software: Microsoft Windows (the CD is not Mac compatible), a Web browser (Microsoft Internet Explorer, Netscape Navigator, etc.), a media player, Adobe Acrobat Reader, Microsoft Word, Microsoft PowerPoint, Microsoft Excel, and Corel WordPerfect. For some links, such as QuickTime 6, you will also need a live Internet connection.

The cost of this CD is $10.00. Request item #WWCDRG68.

Low-Pressure Pipe Sewage System Installation and Design

Theo B. Terry

Design and installation methods are crucial for obtaining proper low-pressure pipe (LPP) system performance. The Lincoln Trial District Health Department (Kentucky) prepared this manual, which is intended to be used as a voluntary reference for installers, inspectors, and users of LPP sewage disposal systems. The table, charts, figures, and instructions in this manual give detailed step-by-step procedures to use when designing LPP systems. A video titled *Low-pressure Pipe Sewage Disposal System, Design and Installation,* also a National Small Flows Clearinghouse product (#WWVTDM100) can be used in conjunction with the manual as a tool to train inspectors and certified installers. This manual will be helpful to engineers, planners, managers, public health officials, operators, and contractors/developers.

The cost of this booklet is $4.00. Request item #WWBLDM101.

Pumping Your Septic Tank

Teri King and Jodie Holdcroft

Septic maintenance can extend the life of your septic system, protect water quality, and also help protect public health. This brochure explains why it is necessary to regularly pump your septic tank. It lists the information that the pumper should include on a receipt, such as tank size, construction, and number of compartments; effluent levels, tank condition, and scum and sludge levels; baffle condition; outlet baffle effluent filter; pump chamber and pump; drainfield condition; sewage disposal location; and any abnormal findings. The brochure includes a brief description about watertight septic tanks. Homeowners, public health officials, and local officials will find this information useful.

The cost of this brochure is 40 cents. Request item #WWBRPE71.

Landscaping Your Septic Tanks

Teri King and Jodie Holdcroft

In developing a site, it is important for homeowners to prepare a comprehensive plan for the property. This brochure describes different ways to plan a landscape design for optimum septic tank operation. Information is provided about such topics as knowing your septic components for easy access, choosing the right plants, and a plant list. This brochure will be useful for homeowners as they landscape the area around their septic system.
The cost of this brochure is 40 cents. Request item #WWBRPE72.