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

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.

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.

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.

Barbara Hartley Grimes, Ph.D., is the NonPoint Source Pollution Program coordinator and **Steve Steinbeck, P.G.**, NonPoint Source Pollution Program team leader with the Onsite Wastewater Section of the Division of Environmental Health, North Carolina Department of Environment and Natural Resources. **Aziz Amoozegar, Ph.D.**, is a professor in the Department of Soil Science at North Carolina State University.

References

1. Ali, Arshad, Moh Leng Kok-Yokomi, and J. Bruce Alexander. 1991. Vertical Distribution of *Psychoda alternata* (Diptera: Psychodidae) in Soil Receiving Wastewater Utilized for Turf Cultivation. J. of Mosquito Control Association: Volume 12, Number 2:287 –289.
2. Amoozegar, Aziz and Wayne P. Robarge. 1999. Evaluation of Tire Chips as a Substitute for Gravel in the Trenches of Septic Systems. Final Report for the Division of Pollution Prevention and Environmental

Assistance; Department of Environment and Natural Resources and Chatham County Board of Commissioners. 133 pp. **http://www.p2pays.org/ref/03/02627.pdf**

3. Burnell, B.N. and McOmber, G. 1997. Used Tires as a Substitute for Drainfield Aggregate: Site Characterization and Design of On-site Septic Systems. ASTM STP 1324: MS Bedinger, JS Fleming, & AI Johnson, Eds. Am. Society for Testing Materials.
4. Daniels, Joe and Bruce Bird , 1993 . A Report on the Use of Scrap Tire Shreds as Soil Absorption Media. Prepared for the Kansas Department of Health an Environment Local Protection Plan Grant. 8 pp.
5. Feuchen, McGarry, and Marc eds. In "Water Wastes and Health in Hot Climates". Flies causing Nuisance and Allergy 1977 John Wiley, New York p. 291-298.
6. Envirologic, Inc. (1990), "A Report on the Use of Shredded Scrap Tires in On-Site Sewage Disposal Systems," by Envirologic, Inc., Brattleboro, Vermont, for Department of Environmental Conservation, State of Vermont, 9 p.
7. Gunasekara, A. S., J. A. Donovan, and B. Xing. 2000. Ground discarded tires remove naphthalene, toluene, and mercury from water. Chemosphere 2000 Oct. 41(8):1155-60.
8. Liu, H.S., Mead, J.L., and Stacer, R.G. (1998).Environmental Impacts of Recycled Rubber in Light Fill Applications: Summary and Evaluation of Existing Literature. Technical Report #2. Plastics Conversion Project. Chelsea Center for Recycling and Economic Development, University of Massachusetts, Lowell. 18 p.
9. North Carolina Solid Waste Management Annual Report (1996- June, 1997) March 1998. Published by: Division of Waste Management; Division of Pollution Prevention and Environmental Assistance, and Department of Environment and Natural Resources 25 pp.
10. North Carolina Solid Waste Management Annual Report (1999- June, 2000) March 2001. Published by: Division of Waste Management; Division of Pollution Prevention and Environmental Assistance, and Department of Environment and Natural Resources 25 pp. **http://wastenot.enr.state.nc.us/swhome/annrep.htm**
11. NYS Roundtable Consensus on Tire Management Parameters for Legislative Development: March, 2000. **http://www.rma.org/scrap_tires/state_issues/index.cfm**
12. Onsite Wastewater Section—Division of Environmental Health—NC Department of Environment and Natural Resources Web Page: Rules, Information, Programs, Innovative and Experimental Approvals/ Applications, etc. **http://www.deh.enr.state.nc.us/oww/**
13. Robinson, Sharon J. (Feb.) 2000. The Use of Chipped Tires as Alternate Aggregate in Septic System Leach Fields, MS thesis in Civil Engineering. State University if NY. Syracuse.234pp
14. Scott, Harold George. 1961. Filter Fly Control at Sewage Plants. The Sanitarian: Vol. 24(1): 14-17.
15. Steinhaus, E. H. and F. J. Brinley, 1957. Some relationships between bacteria and certain sewage-inhabiting insects. *Mosquito News* 17:299-302.
16. Sengupta, S and H. Miller, 1999. Preliminary Investigation of Tire Shred for Use in Residential Subsurface Leaching Field Systems: A Field Scale Study. Technical Report #12. Chelsea Center for Recycling and Economic Development, University of Massachusetts, Lowell. 12 p.
17. Sengupta, S and H. Miller, 2000. Investigation of Tire Shred for Use in Residential Subsurface Leaching Field Systems: A Field Scale Study. Technical Report #32. Chelsea Center for Recycling and Economic Development, University of Massachusetts, Lowell. 33 p.
18. Spagnoli, J, AS Weber, and LP Zicari, September 2001. The Use of Tire Chips in Septic System Leachfields. Center for Integrated Waste Management, University at Buffalo, Buffalo, New York. 92pp.
19. TNRCC Information: The Composition of a Tire: Waste Tire Recycling Program Office of Permitting, Texas Natural Resource Conservation Commission , P.O Box 13087. Austin, Texas 78711-3087.September 1999
20. TNRCC Information: Using Tire Shreds in On-Site Sewage Facilities (Septic Systems) 11-3087. September 1999.
21. USEPA, August, 1999. A Quick Reference Guide. 1999 Update. EPA-530-B-99-002.
22. Usinger, R. L. and W. R. Kellen, 1955. The Role of Insects in Sewage Disposal Beds. Hilgardia. J. of Agricultural Science (California Agricultural Experiment Station). Vol. 23(10): 263-321.

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 float-ing 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 subsur-face sewage effluent absorp-tion systems shipped from ap-proved 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 pur-chasing tire chip coarse aggre-gate shall retain a copy of the freight bill-of-lading as docu-mentation of the tire chip ag-gregate 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 oper-ation 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 ag-gregate shadowing by sleeving the dis-charge pipe laterals within the perforated pipe [which meets Rule .1955(e)] typi-cally used for con-ventional nitrification lines. 2. The minimum ver-tical separation re-quired by Rule 15A NCAC 18A .1955(m) shall not be reduced, notwithstanding the use of any advanced wastewater treat-ment system.	1. Any tire processor wishing to provide tire chip aggregate for use in onsite sewage treatment and disposal sys-tem 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 speci-fications in II of this approval ; Tire processors shall sub-mit 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