

On-site wastewater treatment systems

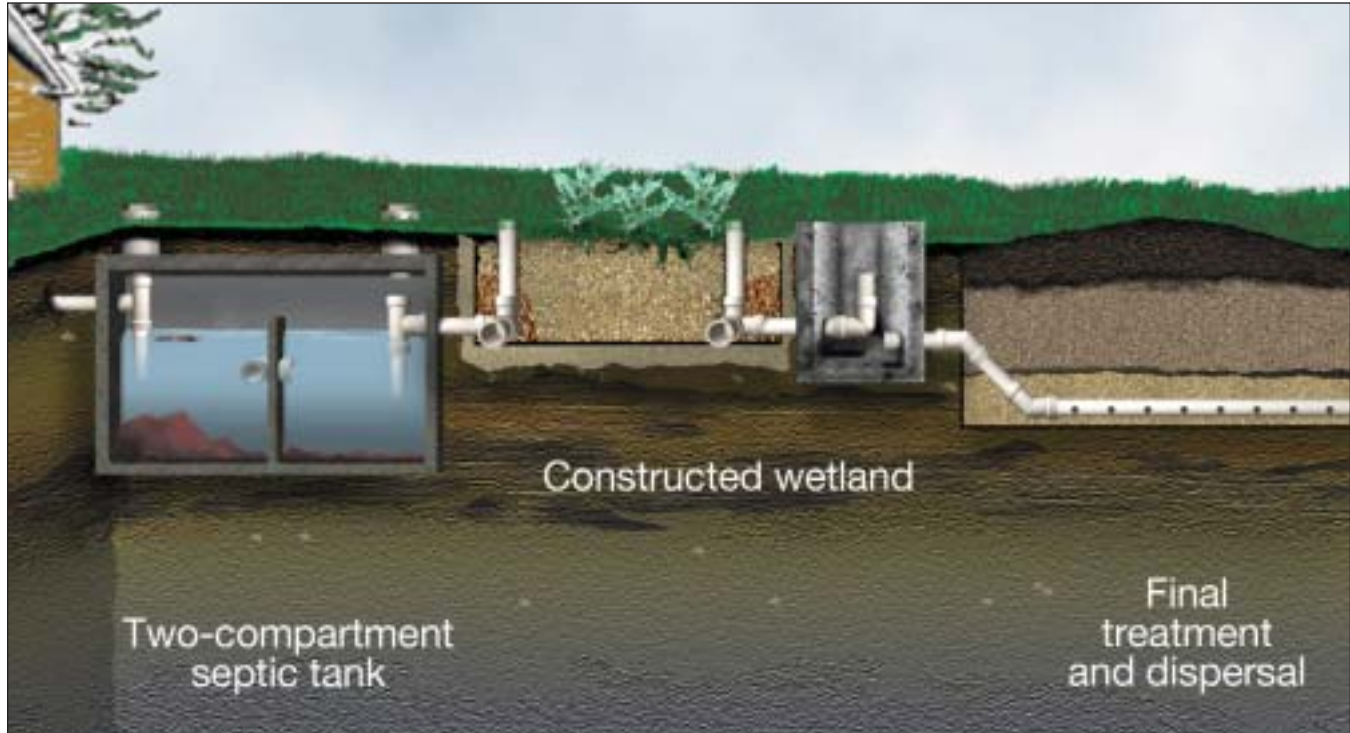


Figure 1: A subsurface flow constructed wetland system for residential wastewater treatment.

Constructed wetland media

Bruce Lesikar, Richard Weaver, Amanda Richter and Courtney O’Neill

Professor in Biological and Agricultural Engineering, Professor in Soil and Environmental Microbiology, Research Associate, and Extension Assistant
The Texas A&M University System

To treat household wastewater effectively, subsurface flow constructed wetland systems must contain the right kinds of media, such as sand, gravel or tire chips; the media must be configured properly; and the system must be maintained regularly.

Subsurface flow constructed wetlands provide advanced treatment of residential wastewater. In a typical constructed wetland system, wastewater (or effluent) is treated in three steps. After it leaves the house, the effluent receives:

1. Primary treatment in a septic tank. There, the suspended materials are removed from the wastewater.
2. Advanced treatment in the constructed wetland. The wastewater flows from the septic tank into the wetland cell, which is a lined basin filled with porous media and plants. It is in the wetland cell that most of the physical, chemical and biological treatment of the effluent occurs.
3. Final treatment and dispersal in the soil. After leaving the wetland, the effluent is dispersed to a drain field via gravity or pressure-dosed systems. At this stage, the soil polishes, or further treats, the wastewater and reclaims the water into the environment.

Functions of the media

The media in a constructed wetland provide a path through which wastewater can flow and surfaces on which microorganisms can live. As the wastewater passes through the pores

between the media particles, the microorganisms living there feed on the waste materials, removing them from the water.

The wastewater also is treated by other processes as it flows through the media, including:

- ✓ **Filtration**, the trapping of suspended materials in the pore spaces between the media particles
- ✓ **Sedimentation**, the settling of suspended particles from the wastewater as it passes through the wetland. These particles will accumulate in the bottom of the wetland medium.
- ✓ **Nitrification**, the conversion of ammonia to nitrate under aerobic conditions (in the presence of oxygen) in the wetland
- ✓ **Denitrification**, the conversion of nitrate to a gas under anoxic conditions (without oxygen) in the wetland
- ✓ **Adsorption**, the removal of wastewater contaminants through attachment to the media or biofilm surface, which is a layer of microorganisms living on the surface of the media and on the plant roots
- ✓ **Assimilation**, the incorporation of wastewater contaminants into microbial organisms or plants growing in the wetland

Another function of the media is to support the plants growing in the wetland. Because no soil should be present in a subsurface flow wetland, the medium is what holds the plants in place.

Particle size

The size of the media particles greatly affects the system's ability to function. Compared to media made up of large particles, media with small particles have:

- ✓ Smaller pores, so they can filter smaller particles from the wastewater.
- ✓ More surface area, where treatment occurs. The microorganisms that feed on the waste materials live on the media surfaces.

If the particles are too big, the effluent does not have enough contact with the biofilm on the media surfaces for proper treatment.

- ✓ Better ability to reduce transmission of odors and vectors, which are organisms (such as mosquitoes) that can carry diseases. Media with large particles have large openings that allow good air exchange, which can allow odors to exit or vectors to enter.

However, systems with small particles clog more often than those that contain media with large particles. Thus, in choosing the media for a con-

structed wetland system, you must compromise on particle size: The particles must be small enough for treatment, yet large enough to allow water to flow through the bed.

Characteristics

Various types of media are used in constructed wetlands. When choosing fill media, consider:

- ✓ **Bulk porosity**: This is the amount of space between media particles that can be filled with air or water. Ideally, bulk porosity should be about 30 percent, which allows the effluent to flow adequately through the wetland cell, yet provides adequate contact time with the media.
- ✓ **Pore size**: Even if a medium has at least 30 percent bulk porosity, the individual pore spaces must be large enough to resist clogging by organic matter.
- ✓ **Stability**: The media must be made of a substance that will not break down over time.
- ✓ **Media size**: Proper media size affects the pore size, surface area, permeability and functionality as a barrier. Particles must be small enough for treatment yet large enough for adequate water flow.
- ✓ **Surface area**: Media particles that are too large do not have enough surface area for the microorgan-

Table 1: Comparison of media used in constructed wetlands systems.

Particle size	Pros	Cons
Sand	Readily available	Difficult to obtain clean sand Easily clogged as microbes grow Pore size too small
Gravel (⅜ inch)	Readily available	Pore size too small Easily clogged as microbes grow
Gravel (⅝ to ¾ inch)	Ideal size Good porosity	Not readily available Costs more because of limited availability Good barrier to odors
Concrete gravel (½ to 2 inches)	Ideal bulk porosity (32 percent) Readily available	Nongraded (most small particles removed) Fewer large openings because of variability in media sizes
Gravel (more than 2 inches)	Good permeability Lower plugging potential	Less surface area for microorganisms Large openings may allow vectors such as mosquitoes to enter and odors to exit
Chipped tires	Relatively inexpensive	Appearance, low aesthetic value Lightweight Steel rusts and discolors effluent

isms to attach and colonize, which could result in poor wastewater treatment.

- ✓ **Uniformity:** All medium particles should be about the same size. If they are of varying sizes, the small particles will fill the pore space between the larger particles and thus fill up the larger pores.
- ✓ **Permeability:** The relative ease with which water can flow through the media is affected by the size of the pores as well as the interconnection of the pores.
- ✓ **Aesthetics:** Appearance is critical for homeowners. The constructed wetland should appear to be a rock garden in the landscape. A medium may have a great functional value but create an “eyesore” in the landscape.

Choices

The most common fill medium is gravel, which is available in several sizes. Graded gravel (gravel particles that are of uniform size) has more pore space than nongraded gravel because the smaller particles in nongraded gravel will fill the pore spaces left by the larger particles.

To select the appropriate medium for a wetland, consider both quantitative properties, which address the performance of the medium in the wetland, and qualitative parameters, which address a homeowner’s satisfaction with the appearance of the wetland.

The type of gravel used can affect the long-term performance of the system. For example, quartz river rock is very suitable in a wetland application. Limestone is less suitable because if it is soft, it can dissolve and plug the wetland. The limestone must be hard enough to resist breaking down over time.

Because in some regions gravel is scarce and waste tires abundant, tire chips increasingly are being used as a fill medium. Waste tires make a suitable substitute for gravel if they are chipped into about 2 inch, square pieces, ½ inch to ¾ inch thick. In a constructed wetland, the biofilm coats rubber tire chips just as well as it coats gravel.

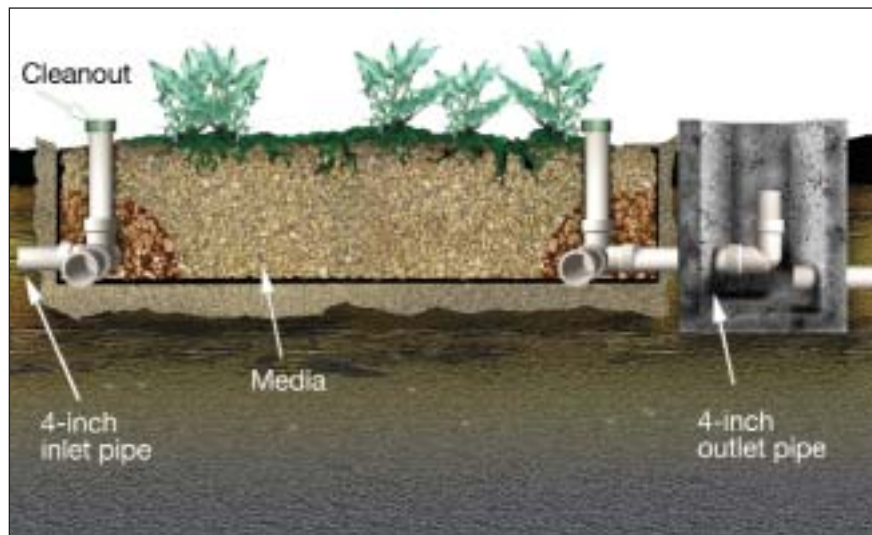


Figure 2: A constructed wetland is a bed of media where water flows beneath the surface and plants grow on top. Larger media are placed near the inlet and outlet pipes to reduce clogging.

Tire chips are less dense and less expensive than gravel. Because of their lower density, they are cheaper to haul. Tire chips have a greater bulk porosity than gravel, so the wastewater is detained longer in the cell. The longer the effluent is in contact with the media, the more pollutants removed and the better the quality of the wastewater treatment.

Tire chips pose disadvantages, however: Those made from radial tires have steel belts and wires around the tire rims that protrude from the chips. This iron can reduce the available phosphorus content of wastewater. This reduced phosphorus content, however, lasts only 1 to 2 years. Tire chips are also less attractive than gravel as a bed medium.

If you are interested in using tire chips in a constructed wetland, your designer or installer may know where to buy them. If not, the Texas Commission for Environmental Quality maintains a list of tire-chip processors on its Web site at: http://www.tceq.state.tx.us/assets/public/comm_exec/pubs/sfr/069_03.pdf

Configuration

Wetland beds can contain two or more types of media in different layers. Generally, the larger media particles are placed on the bottom and a differ-

ent type of media, generally consisting of smaller particles, is placed on the top.

For example: A layer of 2- to 5-inch rock on the bottom of a cell can be covered with ¾-inch rock on the top. This configuration generally is used only on large, community-scale wetland systems. Another example is placing chipped tires on the bottom and smaller rock on top.

There are several reasons to layer the media, including safety, aesthetics, effluent treatment and water flow. Placing a few inches of gravel on top of tire chips can help hold plants in place, as well as address safety concerns from the exposed wire in the tire chips. Gravel is also used above tire chips for aesthetic reasons.

Placing smaller media over larger media will also prevent direct access to wastewater, which can be a breeding ground for mosquitoes and a danger to pets and small children.

However, the vertical layering of the wetland can be disrupted during maintenance. When you remove plants from the wetland, the media layers are mixed, with the surface media moving down into the lower layer and the lower media moving up into the surface layer. Keep this in mind when maintaining your wetland.

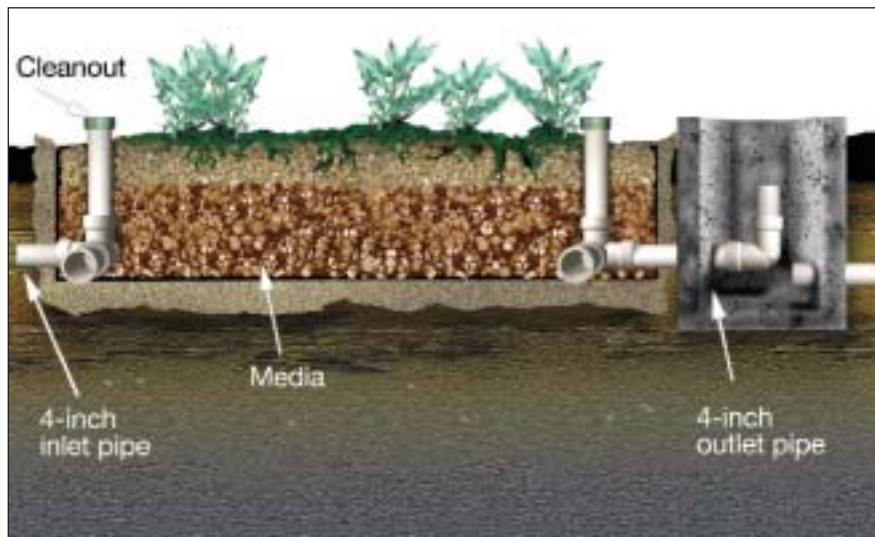


Figure 3: In this constructed wetland, a layer of larger media is placed below a layer of smaller media for greater safety and to improve aesthetics, treatment and water flow.

The most effective approach may be to remove the surface plant material without disturbing the plant roots. The roots may be allowed to decay in the wetland cell and pass through the system.

Another consideration for media configuration is the tendency of systems to clog near the inlet. There, more solids are present in the effluent, and the biofilm buildup is greater. Place larger media at the inlet of the system to reduce the risk of clogging

and to help distribute the wastewater across the inlet.

How to keep it working

To keep a constructed wetland system working properly, you must maintain all of the components in the system, including the septic tank, the wetland and the drain field. Other maintenance includes:

- ✓ Place an effluent filter on the outlet of the septic tank to decrease the number of solids entering the

wetland cell and therefore increase the life of the wetland media. Over time, the effluent flow slows as solids clog some pore spaces. The biofilm will continue to grow as long as it has a constant supply of food (the wastewater). As the biofilm grows, it also will start to clog the pores. When it becomes too heavy, it will slough off and fall through the pores of the system.

- ✓ Remove dead plant material to help keep the system free of debris. Debris on top of the wetland cell can settle into the media and clog the system as it decomposes.
- ✓ Prevent soil from entering the wetland because soil can fill the pores. If the medium is filled with soil or solids, you will need to remove the medium and replace it with clean medium.
- ✓ Periodically remove plants from the wetland bed and replant to help maintain the pores needed for water to flow through the wetland cell. It is important to keep the pore spaces open in the medium. Very dense plants on the surface clog the wetland because their roots take up all the available pore space.

For more information, see Extension publications, L-5227, "Septic Tank/Soil Absorption Field," and L-5230, "Constructed Wetlands."

The On-Site Wastewater Treatment Systems series of publications is a result of collaborative efforts of various agencies, organizations and funding sources. We would like to acknowledge the following collaborators:

Texas State Soil and Water Conservation Board
 Texas On-Site Wastewater Treatment Research Council
 Texas Commission on Environmental Quality
 USDA Water Quality Demonstration Projects
 Consortium of Institutes for Decentralized Wastewater Treatment

USEPA 319(h) Program
 Texas Cooperative Extension
 Texas Agricultural Experiment Station
 Texas On-Site Wastewater Association
 USDA Natural Resources Conservation Service

Produced by AgriLife Communications and Marketing, Texas A&M System
 Extension publications can be found on the Web at: <http://AgriLifebookstore.org>

Visit the Texas AgriLife Extension Service at <http://AgriLifeextension.tamu.edu>

Educational programs of the Texas AgriLife Extension Service are open to all people without regard to race, color, sex, disability, religion, age, or national origin.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Edward G. Smith, Director, Texas AgriLife Extension Service, Texas A&M System.