RENOVATION OF A FAILED DRAINFIELD

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Onsite wastewater treatment systems have long been viewed as temporary solutions, waiting on the nearby city to extend the conventional sewer “big pipe” to solve the problems created by failing septic systems. As federal grants and loans have either greatly diminished or total disappeared, a new emphasis has been placed on permanently sustainable wastewater treatment systems for individual homes. The decentralized industry is now developing strategies and conducting research on how to successfully fulfill this mission. Part of this strategy is how to deal with millions of existing conventional onsite systems that will almost certainly fail before the home or structure’s useful life is complete.

The key to creating sustainable systems is to eliminate the very causes of system failure. Most industry professionals agree that the progressive formation and development of a biomat in the leach beds is the usual cause of failure. Unfortunately, the formation and existence of a biomat is credited with effluent distribution and greatly assisting in the treatment of septic tank effluent before it is transported away from the disposal system. The biomat is generally comprised of organic compounds and anaerobic bacteria which accumulate along the surface of the disposal trench. The “typical” trench is filled with anaerobic effluent from the septic tank and the biomat which has accumulated over a period of time. The term “progressive failure” is often applied to this process, because the biomat will continue to grow and become increasingly thicker as the system matures, until the movement through the biomat is less that the amount of effluent coming into the trench from the septic tank, causing a surfacing of effluent.

There are many variables impacting the time and rate of biomat growth:

a. Strength of wastewater  
b. Volume of effluent applied to trench surface  
c. Type of soils the trench is installed  
d. Depth to restrictive layer(s)  
e. Many other factors

Regulators have typically focused on the soils aspect of these variables. Indeed, well drained soils will yield the longest lived system. This is a rational approach, given that it is practically impossible to mandate strength of wastewater or water use by individual homeowners. However, there is a significant fallacy in this logic. Deep well drained soils will not necessarily treat septic tank effluent effectively. These soils are typically far from permeable and effluent moves directly into an anaerobic zone without proper treatment for pathogens and organics.

Septic tank effluent has many constituents, but the one most critical for the treatment analysis is Ammonia (NH₃). The nitrogen cycle of nitrifying Ammonia (NH₃) to Nitrate

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(NO₃) (an aerobic process) and then denitrifying nitrate (an anaerobic process which must have carbon source) to CO₂ + N is basic to understanding the success or failure of a leach field. Conventional leach field trenches operate in an anaerobic environment, practically eliminating the conversion of ammonia to nitrate. This enables the formation of the biomat which aids treatment but eventually causes failure of the trench.

Nitrification of ammonia is easily accomplished in practically all aerobic treatment processes. Packed bed treatment, aerobic plants and many other technologies routinely nitrify over 95% of ammonia during their treatment process. Some treatment systems also have denitrification capabilities. While not a focus of this paper, treatment also reduces the bacteriological component of the effluent. The benefits of adding treatment (nitrification) becomes obvious. The biomat growth in the soils will be greatly reduced, if not eliminated. The soils will retain their permeability, and in many cases will likely improve in structure and the number of macro-pore (larger opening created by earthworms and other similar organisms) development. The nitrification of ammonia also creates a less toxic environment for aerobic organisms.

If a revised program was to stop with simply adding a high level of treatment, the number of surface failures would drop to a relatively small percentage. Unfortunately, as our knowledge of subsurface systems has grown, we now realize pollution of ground water and nearby streams is just as damaging as surface failures. Leaching nitrified effluent at relative deep depth (18” to 30”) in most cases will eliminate the opportunity for denitrification because the carbon source needed for denitrification is only found in the organic layer of the soil – generally 6” to 12” deep. To accomplish denitrification, the nitrified effluent must be place in the organic layer. To effectively nitrify, this must be an anaerobic zone, which requires a restrictive layer just below the organic layer. This obviously creates a new way of evaluating soils, which values shallow pans over deep well drained soils.

This project to renovate a failed drain field began as an alternative to installing a large Wisconsin Mound at a residence in Williamson County, Tennessee. This particular home had a failing leach field since the first year or second year after it was built in the early 1980’s. The owner wanted to fix the system. The county health department had offered the homeowner the option of a very large modified “Wisconsin Mound” constructed over the existing leach field. The owner sought other less costly and more visually appealing alternatives to a large mound in their back yard. Pickney Bros. Inc. agreed to design, install, and monitor this site for five years as part of a demonstration program – to promote advanced treatment for one-home systems in Tennessee. Actual construction was completed in July of 1999. The goal of this study was to effectively measure the recovery rate of the failed leach field lines by dosing these line with highly nitrified effluent. The basic plan for the system was:

1. All domestic waste flows from home into a 1500 septic tank
2. Effluent from septic tank flows by gravity to a 1500 dose tank
3. Intermittent Sand filter is dosed approximately every 30 minutes from dose tank with a small amount of effluent.
4. Effluent is treated by aerobic microbes attached to sand particles in the sand filter.

5. Highly nitrified effluent is dosed evenly throughout the existing leach field using a Low Pressure Pipe distribution system. Dissolved oxygen in the sand filter effluent should range from 6 to 9 mg/100 ml.

6. Drain field would be renovated by aerobic microbial consumption (removal) of existing biomat.

7. Flow meters are installed in the dosing system and are electronically recorded by a Programmable Logic Controller (PLC).

8. A collection system is installed in the field lines to permit line to be drained any time after the system has been dosed. A meter is installed in the return line to permit measure of effluent not absorbed into the soils around the leach beds. All activities, including rainfall, surrounding the operation of this system were recorded by the PLC.

The leach field was installed in a soils unit described as mimosa. The soil scientist for Williamson County described the soil as: “This massive, plastic, structure less clay horizon will not absorb in any manner as is necessary for the use of any type subsurface sewage disposal system. Percolation tests conducted in such soils always yield MPI rates of infinity.” The NRCS manual describes this soil: “The slope, the slow permeability, low strength and moderate shrink swell potential are limitations affecting most urban uses.” This site like many others in the county were approved based on “highly suspect” percolation tests. The soils have a high clay content with very little structure. On the positive side, this soil unit was “well drained” with no indication of mottles in the upper 36 inches. Leach field lines we installed between 30 and 36 inches deep.

The System was completed, and placed into service in July 1999. The leach beds were drained during the installation of the Low Pressure Distribution, so the lines were empty at system startup. The initial setting was to dose approximately 150 gallons per dose, and then drain the leach beds 2 hours later and measure water returned to the dose tank. Unfortunately, no water was ever returned from the collection system. The thick heavy biomat was apparently removed in a short amount of time. Inspection of the system several months after the system was placed in operation revealed that no biomat was left to block infiltration into the soil.

During the next several years, no ponding has been evident in the leach fields, and the system has performed without incident. Unfortunately, no usable data was collected on the elimination of the biomat other than to reinforce the concept that the biomat can be eliminated very quickly using highly nitrified effluent. As of yet no research has been conducted to evaluate the potential pollution of ground water with nitrate from this system. Given the relative fast movement from the leach bed trenches, it is likely the final denitrification is relatively limited.

This site was selected due to the “very poor” soils, with the logic that if this site can be renovated, then almost any site can be renovated.
The formation of the biomat can be directly related to the amount of oxygen available in the conventional leach bed for bacteria to process organic compounds. Research to date has been ineffective in measuring the “normal transfer of oxygen” into subsurface layers. However, it is readily apparent that the leach bed remains in a constant anaerobic state. The simplest calculation is to measure the pounds of Biochemical Oxygen Demand (BOD) required for the design flow into a system, and the dissolved oxygen delivered in the wastewater, assuming no transfer of oxygen through the soil. If the amount of available oxygen exceeds the demand, no organic biomat would likely be formed. Below is the table detailing these calculations for a design loading condition, actual loading condition and actual loading condition after the sand filter was installed. The household was only using approximately 150 gallons per day during the failure mode. The system had 360 LF of leach field with 3 feet wide trenches. Testing of septic tank effluent confirmed that the household waste was in the normal range, so the assumed untreated effluent strength was a BOD of 150 mg/l.

<table>
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<th>MODE</th>
<th>FLOW GAL/DAY</th>
<th>UNIT FLOW GAL/SF</th>
<th>BOD MG/L</th>
<th>BOD LB PER DAY</th>
<th>BOD LB PER DAY PER SF</th>
<th>DO MG/L</th>
<th>DO LB PER DAY DEMAND/SUPPLIED</th>
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<td>DESIGN</td>
<td>450</td>
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<td>.00052</td>
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<td>.00018</td>
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<tr>
<td>RECOVERY % of Design</td>
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<td>3</td>
<td>0.004</td>
<td>0.6%</td>
<td>7.5</td>
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Operating under design loading of 450 gallons per day with an average BOD of 150, the system dissolved oxygen deficit is 0.56 pound per day. Using highly nitrified effluent, a surplus of oxygen is delivered to the leach field, allowing biomat to use available dissolved oxygen from the sand filter effluent to create the appropriate aerobic conditions to break down biomat, and return soils to a permeable state.

These results point to a very logical conclusion that while soils are a very important consideration in designing a septic system, many other factors should be considered to create truly sustainable onsite systems. Advanced treatment and proper management of these treatment processes will certainly become a very important consideration as our industry moves toward sustainable infrastructure. Nitrate and Phosphorus migration to groundwater and water bodies may prove to be the more important consideration when permitting and designing onsite systems.