USING IN-SITU SOILS AS AN ATTACHED GROWTH BIOREACTOR FOR TREATMENT AND DISPOSAL OF RESIDENTIAL SEWAGE

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The Ohio Health Department's 2007 regulations regarding the on-site treatment and discharge of residential sanitary sewage specify that there be a minimum distance of natural soil between the bottom of the leach pipes and any subsurface "limiting condition." Site-specific soil testing by a certified soil scientist is used to determine the presence of any limiting conditions such as bedrock or a seasonal high groundwater table. If sufficient distance between the leach pipes and this limiting condition is not present, then the dispersal system must be converted to a more costly alternative such as an elevated leach field, mound system, or drip irrigation system.

For the relatively slow draining soils prevalent throughout Ohio, it is the seasonal high groundwater table, also referred to as a perched aquifer, which is typically identified as the limiting condition for most sites. Whether "seasonal water" should be considered a limiting condition, when disposing of septic tank effluent in soil, is frequently questioned. The concern with this elevated layer of groundwater is that it could back-up into the leach lines or prohibit full treatment of the sanitary sewage from occurring before the wastewater reaches the groundwater. However, the ability to improve site drainage and actually lower the level of seasonal groundwater through the use of subsurface drainage tiles, as is frequently done within agricultural fields, presents an opportunity to potentially eliminate these concerns with seasonal high groundwater.

An experiment involving the use of subsurface drains within a traditional leach field was conducted in Blount soil in Union County, Ohio, from October 10, 2010 until May 30, 2011. This experiment demonstrated that with two 3-foot wide by 110±-foot long traditional leach trenches and three engineered drainage tiles separated by 2.0± feet of Blount soil horizontally and 2.5± vertically resulted in a discharge of water which meets the requirements for surface water discharge under most National Pollutant Discharge Elimination System (NPDES) permits issued by the Ohio Environmental Protection Agency (EPA). The water appeared clear, with no odors, e-coli of <114 cfu/100 ml and fecal coliform of 214 cfu/100 ml. The BOD levels ranged between 3 and 5 mg/l with an average of 3.6 mg/l. The actual laboratory results are shown in the following table.

HSTS Experiment
Engineered Drainage Tile Discharge

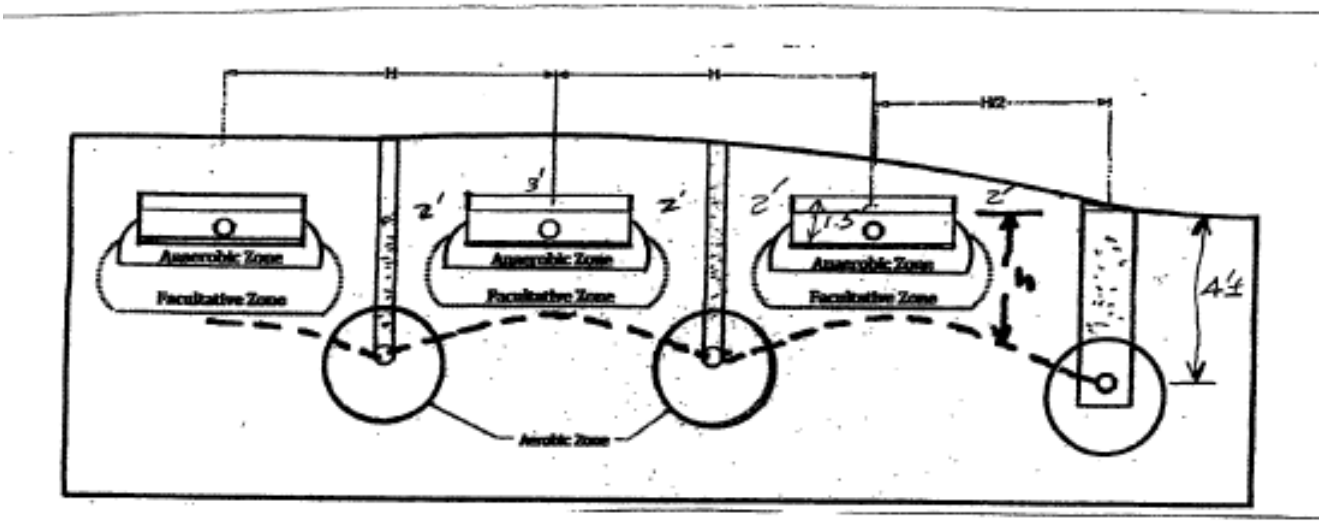
Date	Ecoli (cfu/100 ml)	Fecal Coliform (cfu/100 ml)	BOD (mg)	Flow (gpd)
12/10/2010	100	100	n/a	216
12/20/2010	<50	150	n/a	234
3/8/2011	300	650	5	1,440
3/28/2011	50	150	<3	340
4/10/2011	<50	200	3	720
4/15/2011	<50	100	4	360
5/22/2011	200	150	<3	720
Avg of 7 samples	**114**	**214**	**3±**	***575±***

Flow turned on Oct 10, 2010.
No flow in drains until after rain on Nov. 5, 2010 (1.66" rain).
Limit by New Law: Ecoli = 1,000 cfu/100 ml.
Limit by New Law: Fecal coliform = 5000 cfu/100 ml.

Within this experiment, the leach trench received the discharge from a typical septic tank serving a family of five. Wastewater sampling was usually 2± days following a rainfall or immediately before any rainfall. Despite the test period encompassing the wettest spring on record, the dispersal field showed no signs of standing surface water which is typically considered to be an indication of a failing leach field. The existing leach field of this same residence that did not receive any wastewater frequently had water levels that were flush with ground surface during much of the same period.

By lowering the seasonal high groundwater table with the subsurface drainage tiles, it is believed that an anaerobic—facultative-aerobic attached growth bioreactor is created using the native soils as the medium for microbial growth. Attached growth bioreactors are frequently used in traditional sanitary wastewater engineering, but in each case, the bioreactor and the attached growth medium are of manmade materials. In this case, the bioreactor is a natural occurrence.

Typical Leachfield Cross – Section



H – Horizontal Distance

h – Vertical Distance

H - Horizontal Distance
h = Vertical Distance

It typically takes a hydraulic head of 2± feet to force water down through 2± feet of Blount soil. This has been successfully demonstrated in Union County, Ohio. It is theoretically possible for an 8±-foot spacing of engineered drains to lower the drainable water to a curve approximated by the dashed line in the exhibit above. For the test system, it is understood that the wastewater enters the leach trench in an anaerobic condition. As the water migrates downward by gravity, anaerobic microorganisms begin consuming or biologically removing organic material. The tile drains remove all the drainable water creating a hydraulic head which allows the water to migrate through the relatively slow draining soil.

The slow draining soil (approximately 1"± per day) provides the detention time necessary for anaerobic metabolism to occur. As the anaerobic microorganisms and chemical reactions continue, they progress through a zone of facultative (or anoxic) microorganisms which may or may not need aerobic conditions. As gravity continues to pull the liquid downward through the natural soils, the microbiologically driven reactions continue until aerobic microbes dominate the reactions with any remaining organic material until there is very little or none remaining. Simultaneously e-coli and fecal coliform counts of human origin are reduced to acceptable levels.

The critical components that allow this system to be successful are (1) sufficient hydraulic head between the level of water in the leach trench and the drainable water curve in the undisturbed soil and (2) the detention or holding time in the soil. Experience and research in other forms of wastewater treatment processes both aerobic and anaerobic (attached growth or unattached growth) leads this research to the observation that in soil the void volume presents the possibility of adequate detention time to permit the microbes plus biological and chemical reactions to stabilize the organic matter and the human originated bacteria to die off. This should happen just like microbiologist taught us over 50 years ago.

This possibility came from studying all of the attached references, including the old ones and most recent ones plus various research projects over the period from 1956 to 2010. The missing link was research by Dr. Larry Brown and his work at Ohio State University. Also, the past 4 years of reviewing the work of many researchers and articles, none were found that took into consideration the combined importance of hydraulics, microbiology, and void volumes in soil in its natural state to design an on-site dispersal system.

It is believed that this attached growth bioreactor using in-situ soils could potentially be applied to any soil conditions except of those with a high sand or gravel content. All soils drain to some degree. The question is how close together and how deep do the engineered subsurface drainage tile need to be to provide the required drawdown of the seasonal water table, permitting aerobic conditions to exist at the bottom of the process? Also, what is the minimum depth or thickness of a given soil, with its inherent permeability (hydraulic conductivity), that will provide the detention time required to allow the microbiological and chemical reactions to proceed to completion? For example, sand does not provide the necessary detention time because the wastewater moves through the sand to rapidly. Whereas, with the limited research performed thus far, Blount soil has been shown to perform exceptionally well with approximately 24" of soil. There is some evidence that as

little as 12-18" may have been suitable to provide sufficient detention time. Future research may show that the soils clay content as listed in the soils report or identified in the field may be the only important parameter to the design of a successful bioreactor.

The issue and controversy over whether or not the presence of a seasonal high groundwater table should be considered a limiting condition can only be answered satisfactorily by research in the real world, by digging in existing systems, by taking samples of leachate in functioning systems, or construction of additional leach field systems as herein described.

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