PROPOSAL TO INVESTIGATE NON-PROPRIETARY MEANS OF REDUCTING NITROGEN IN ONSITE SEPTIC SYSTEMS

Submitted upon request of the Cape Cod Commission made on August 30, 2013

By

Barnstable County Department of Health and the Environment

For studies to be conducted at the Massachusetts Alternative Septic System Test Center

Submitted September 19, 2013

Contact Person:
George Heufelder
Barnstable County Department of Health and Environment
Phone 508-375-6616
gheufelder@barnstablecounty.org

PROPOSAL TO INVESTIGATE NON-PROPRIETARY MEANS OF REDUCTING NITROGEN IN ONSITE SEPTIC SYSTEMS

PROJECT OBJCTIVES:

The performance of proprietary onsite septic system technologies for the removal of nitrogen from wastewater is generally well known (http://www.barnstablecountyhealth.org/ia-systems/information-center/data-and-statistics/ia-box-whisker-diagrams). Conversely, the efficacies of non-proprietary denitrification strategies are less known, primarily due to the lack of financial incentives to develop and promote them. The result of this fact is that our primary understanding of these strategies comes through independent research efforts variously funded though universities and some state and federal grant programs.

In our geographical area, standard septic systems (septic tank-leachfield) have been found to remove 25-35% of the total nitrogen from wastewater. With enhanced nitrogen removal proprietary devices commonly used in Barnstable County, the combined nitrogen removal of the system and the leachfield generally ranges from 65% – 72%. The proposed study seeks to investigate non-proprietary means to remove higher percentages of nitrogen by enhancing and/or manipulating soils-based systems. We consider this work essential in order to assure wastewater planners and managers and the public that these decentralized options are properly evaluated.

This project takes advantage of findings from three publically-financed projects, and one collective of soils-based research efforts:

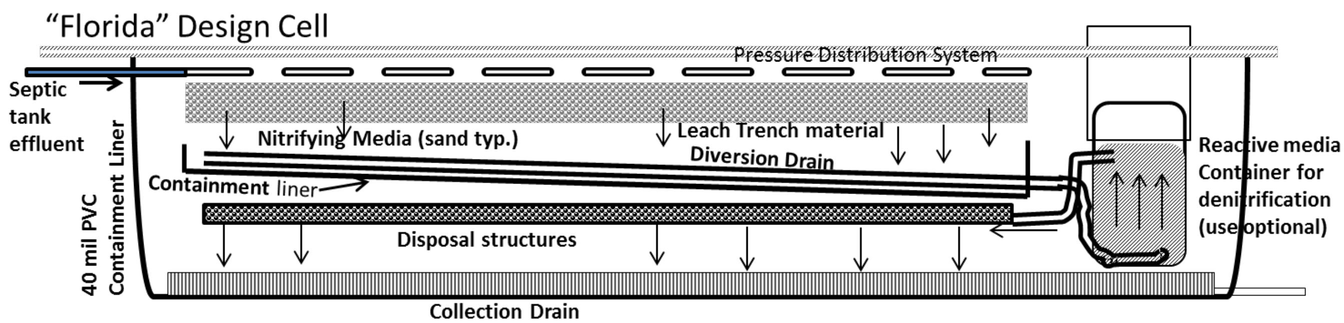
- The Florida Passive Nitrogen Removal Project;
- Past but undocumented efforts near the Waquoit Bay Estuarine Research Reserve (WBNERR) as part of a National Demonstration Project; and
- Recent published results from research funded by the Canadian Water Network Nova Scotia Environment and the Natural Sciences and Engineering Research Council
- Various studies on the effects of system profile and soil texture on denitrification rates

The Florida Passive Nitrogen Removal Project

Beginning in the mid- to late 2000s, while citing a concern over the expense of installing and operating advanced and proprietary onsite treatment units, the Florida Department of Health began efforts to investigate strategies that treat wastewater for nitrogen in the onsite setting using "passive[1]" techniques. Some of these technologies were non-proprietary; that is no manufacturers benefitted directly from their use. These technologies generate little private funding to support continued research. These and other similar efforts supported by Florida Department of Environmental Protection (FDEP) have showed some promise and deserve a critical evaluation for their relevance to our area[2].

[1] "passive" by their definition included systems incorporating the use of up to one pump.
[2] On-Site Sewage Treatment and Disposal Systems Evaluation for Nutrient Removal FDEP Project # WM 928: Final Report Submitted to Florida Department of Environmental Protection By Dr. Ni-Bin Chang, Dr. Martin Wanielista, Dr. Ammarin Daranpob, Dr. Fahim Hossain, Zhemin Xuan, Junnan Miao, Sha Liu, Zachary Marimon,

Ongoing efforts by the Florida Department of Health's Passive Nitrogen Removal Study offer an unprecedented opportunity to determine the transferability of emerging findings to our area. While investigating transferable elements however it will be vital to document the effects of differences in wastewater chemistry such as alkalinity between Florida and our region as well as seasonal differences in temperature that have an anticipated effect on nitrogen removal. Further, Florida's efforts are not complete and hence not all design, treatment and operation challenges have been identified that might also have regional relevance. In close consultation with Damann Anderson, one of the project's lead investigators, we propose to determine the most promising design from that project. Mr. Anderson indicates that one full-scale system has been installed and others are scheduled. For this project, we will install and test the best design to date at the Massachusetts Alternative Septic System Test Center while maintaining the flexibility to alter operational parameters as the Florida efforts develop. The design concept is provided in Figure 1.
.



Discussions with Florida investigators have suggested removal rates of over 90% of total nitrogen using various modifications of this basic design.

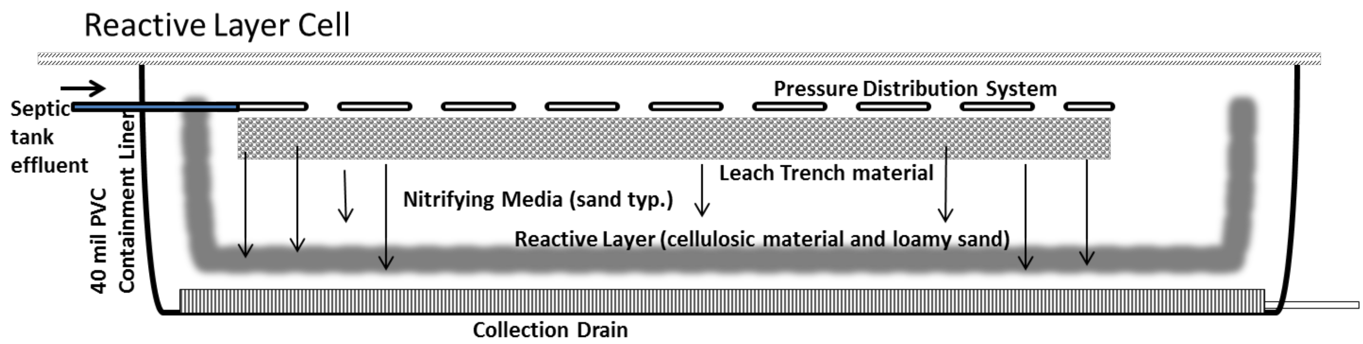
WBNERR Demonstration Project

In the mid-1990's the WBNERR hosted an EPA Demonstration Project that included the installation of a permeable horizontal reactive layer of material placed beneath a standard septic system leachfield at a bed-and-breakfast facility. The results of sampling this system were inconclusive due to the difficulty in obtaining a representative sample beneath the system. Questions regarding dilution and dispersion at the sampling site could not be resolved.

The Test Center facility offers the ability to install a system entirely within a lined containment structure, thus allowing the representative sampling of all percolate. This type of containment is presently being successfully used at the Test Center by National Sanitation Foundation for evaluation of slow-rate filters at the site and we will use this method to obtain data from the barrier design.

We propose to install a similar reactive layer beneath a leaching component (see figure below).

Shalimar Debusk. University of Central Florida's Stormwater Management Academy - Civil, Environmental, and Construction Engineering Department. April 17, 2011.



The system installed will have a minimal vertical profile in an attempt to make overall construction less expensive. The original system in Waquoit was based on an assumption that four feet of sand beneath a soil absorption system was necessary to achieve nitrification of all ammonium (the necessary precursor step for denitrification). Research since that period has confirmed that nitrification can occur in less than one foot of soil passage with low pressure distribution of septic tank effluent. For this system, we propose to install a fully-sized system for at least 350 gallons per day capacity.

Recently-published study design

In 2007-2008 researchers in Nova Scotia, Canada experimented with a concept referred to as contour trenches for purpose of contaminant reduction[2]. Although the study was only intended to demonstrate the differences between gravity and dosed systems, the particular configuration of trenches, aligned along a slope of 10%, effectively acted as a lateral filter and achieved total nitrogen removals of nearly 80%. The purpose of our proposal is to duplicate this work and determine feasibility and applicability to our area.

Using the basic concepts of this design and adapting them for use in areas devoid of 10% contours will present a particular challenge. Questions left unanswered in the Canadian study relate to minimum slope necessary to achieve movement in the lateral filter, the optimal wastewater loading rate and timing to achieve optimal nitrogen removal, and the long-term sustainability of the nitrogen removal. The goal would be to adapt the design for areas where there is minimal or no slope and to present a design that would have the minimum cost.

In this part of the work plan, we will construct a trench (minimum length 20 ft.) and duplicate the study performed in Nova Scotia. Once the nitrogen reduction values are confirmed, we will adjust operational values to optimize nitrogen reduction. The final product will include a design appropriate for our geographical area with feasibility and cost estimates for construction at various wastewater flows.

Shallow drainfields in finer-textured soils

A review of the literature regarding denitrification rates in standard septic systems using various soil types reveals a wide range of total nitrogen reduction values. A common theme in these studies is that finer textured soils alternately dosed and located in shallow soil horizons produce the highest total nitrogen reductions. In certain areas of Rhode Island, this shallow-trench design is being contemplated as

[2] The Effects of Dosed versus Gravity-Fed Loading Methods on the Performance and Reliability of Contour Trench Disposal Fields Used for Onsite Wastewater Treatment. Environ Qual. 2013 Mar-Apr; 42(2):553-61. Doi: 10.2134/jeq2012.0255. Bridson-Pateman E, Hayward J, Jamieson R, Boutilier L, Lake C.

a management practice to reduce nutrient loading (George Loomis, New England Onsite Wastewater Training Program, University of Rhode Island – personal communication).

The present practice in Barnstable County for the placement of leaching components is to avoid the finer textured soils (such as would be located in the A and B soil horizons) and locate the soil absorption components in the fine to coarse sands of the C soil horizon. While this serves well for the hydraulic function of the system, it is one of the major impediments to achieving optimal denitrification.

In this portion of the study, we propose installing a shallow soil absorption system within 6 inches of the surface to disperse septic tank effluent. While we have done this before using medium sand (ASTM C33) and a drip dispersal system, in the proposed installation we propose using two loamy-sand mixtures of soil and a simpler shallow low-pressure dosed system.

Prior to the decision on soil types and hydraulic loading rates, large soil column studies will be conducted with consultation with Jose Amador Ph.D., a professor of soil science and microbial ecology at the University of Rhode Island. This investigator is conducting independent research on nitrogen speciation and removal in soils-based systems and his input will be invaluable in determining appropriate candidate designs.

PROJECT TASKS

Task 1
Confer with investigators in all projects cited to obtain design details and the latest and optimal designs for the five systems to be constructed. This may involve conference meeting, calls and actual visits by investigator where possible.

Task 2
Prepare concept drawings and design plans for the construction of the systems.

Task 3
Conduct limited experiments with soil types using large (42” diameter) soil columns. Compile results and use for input in shallow drainfield systems.

Task 4
Meet with prospective contractors for the construction of systems and choose contractor.

Task 5
Monitor system discharges twice per month for all relevant parameters for at least 18 months.

Task 6
Prepare reports on system performance and recommendations for design and installation of promising systems in our area.

Task 7
Make monthly updates and provide them to the public via the MASSTC.org website

Project Timeline

	October 2013	November 2013	December 2013	January 2014	February 2014	March 2014	April 2014	May 2014	June 2014	July 2014	August 2014	September 2014	October 2014	November 2014	December 2014	January 2015	February 2015	March 2015	April 2015	May 2015	June 2015	July 2015	August 2015	September 2015	October 2015
Task 1 - Confer with researchers to obtain appropriate design for trial																									
Task 2 -Prepare concept drawings and design plans for the construction of the systems																									
Task 3 - Conduct limited experiments with soil types using large (42” diameter) soil columns.																									
Task 4 - Meet with prospective contractors for the construction of systems and choose contractor - install systems.																									
Task 5 - Monitor system discharges twice per month for all relevant parameters for at least 18 months.																									
Task 6 - Prepare reports on system performance and recommendations for design and installation of promising systems																									
Task 7 - Make monthly updates and provide them to the public via the MASSTC.org website																									

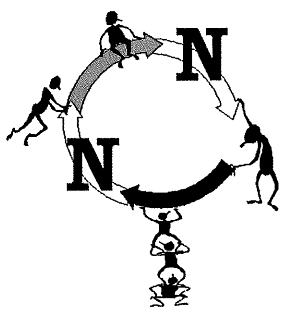
Estimated Project Budget

Estimated Costs	
Project 1 (Florida Design)	$ 20,800.00
Project 2 (WBNERR Design)	$ 16,550.00
Project 3(Nova Scotia Design)	$ 10,750.00
Project 4 (Shallow Drainfields)	$ 11,000.00
Sampling Costs (all projects combined)	$ 53,456.00
Staff Costs (all projects combined)	$ 37,500.00
Grand Total	$ 150,056.00

Background:

Barnstable County, through its Department of Health and Environment has operated the Massachusetts Alternative Septic Systrem Test Center (MASSTC) since 1999. Its continuiung mission is to provide testing, research and information that informs local decisions regarding wastewater management from onsite septic systems. To date the Test Center has tested nearly every proprietary onsite septic system technology that purports to remove nitrogen from wastewater and has conducted independent research under various EPA Section 319(b) grants on the removal of nitrogen and other contaminants using various treatment means.

This project is a natural extension of the Test Center efforts. It endeavors to investigate strategies for nitrogen removal that have no commercial proponents. Using past research and collaborating with top reseachers and practitioners from around the continent we have identified candidate strategies that hold promise to treat wastewater onsite and achieve significant levels of nitrogen removal. The completion of the described study will determine whether these technologies perform and whether they are practical and economical tools able to be used to address in part the wastewater management challenges of Barnstable County.



Nitrogen Removal from Onsite Systems

Are there strategies that can be used to enhance nitrogen removal?

How far can we push the envelope?

What we know –

The most common practice of onsite septic system installation on Cape Cod promotes only 20-30% reduction of nitrogen.

"Place it in the sandy soil and place it deeper in the soil horizon in order to minimize the size of the system"

What we don't know –

Are there ways to optimize nitrogen removal within reasonable practical economic and construction means?

Project Goal – Determine whether there are non-proprietary means for modifying septic system design to increase nitrogen removal/recycling using the most current or recent research.

Project Strategy – Using data developed at the Massachusetts Alternative Septic System Test Center, and collaborating with researchers active in the field, develop a set of candidate non-proprietary septic system designs, install the systems and test them under a protocol that enables their verification that can withstand potential regulatory scrutiny.

Collaborating Efforts

- **Florida Passive Nitrogen Removal Project** – Dr. Damann Anderson, part of the State of Florida Department of Health study.
- **Horizontal Reactive Barriers** – Dr. William Robertson, University of Waterloo
- **Contour Trenches/lateral sand filters** - Rob Jamieson, PhD, Associated Professor and Canada Research Chair in Cold Regions Engineering, Environmental Engineering Program, Dalhousie University
- **Shallow Drainfields in manufactured soils -** José A. Amador, Professor Laboratory of Soil Ecology and Microbiology, University of Rhode Island and George Loomis URI Septic System Training Center

Progress Report on the investigation of non-proprietary means of removing nitrogen in onsite septic systems

Barnstable County Department of Health and Environment
Massachusetts Alternative Septic System Test Center

April – June 2014

Background

In October, 2013 the Barnstable County Department of Health and Environment (BCDHE) received funding from the Cape Cod Commission to investigate means for the removal of nitrogen from wastewater in onsite septic systems. The focus of these investigations was the identification and testing of technology enhancements to septic systems for the removal of nitrogen that are public domain (non-proprietary). Due to its operation of the Massachusetts Alternative Septic System Test Center, BCDHE was to install and test promising candidate technologies using the most appropriate standardized protocol(s) during spring 2014.

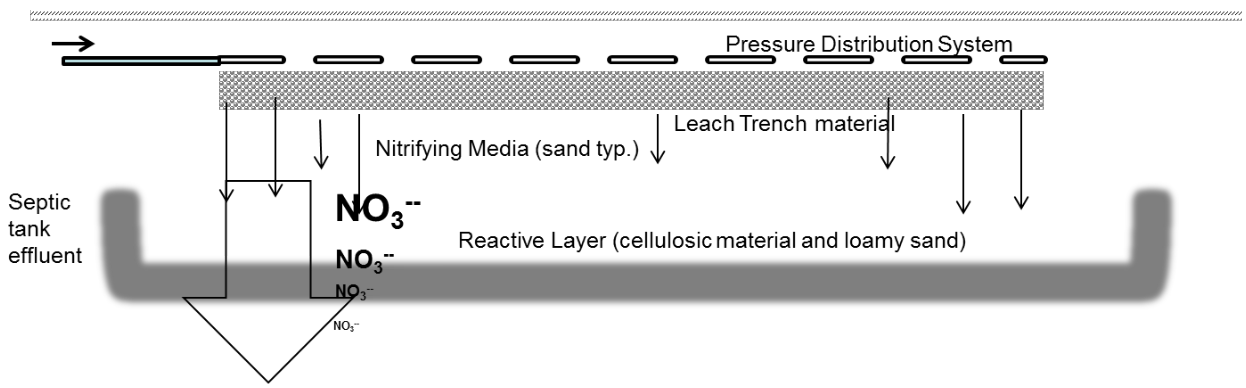
Delays

Due to a sudden interest in the testing of proprietary technologies at the Massachusetts Alternative Septic System, the project has been delayed for the installation of the pilot systems. This delay has allowed for a personal meeting with Damann Anderson (Hazen and Sawyer, Environmental Engineers and Scientists), one of the Florida Passive Nitrogen Removal Project lead investigators. The results of the discussion have informed some preliminary experiments and possible design changes to the systems installed in Florida which may make the system installation more economical and simpler.

Preliminary testing

The focus of our efforts is to adapt those features of other publicly-financed projects to designs that show promise in our area. A series of initial experiments were performed to validate assumptions relating to nitrification and denitrification in our geological setting.

Although not completely dismissed as possible pilot design as was installed in the Waquoit Bay watershed, discussions with Dr. Robertson, University of Waterloo regarding the horizontal reactive barrier has led to a change in design plans. Dr. Robertson has stressed the need to maintain saturation in the reactive layer of material beneath the nitrification zone of the soil treatment unit. Originally, we had planned to use silt mixed with sawdust for the reactive layer (see below)



Under this strategy, we had hoped to maintain the hydraulic conductivity of the mixture concurrent with maintaining saturation. Since silty-loam material is less predictable regarding its continued ability to maintain the hydraulic conductivity necessary to promote final disposal, we have adapted a design to use sand mixed with the sawdust. The saturation will be maintained using an impervious liner that will maintain 18” of saturated mix. This strategy mimics that of Damann Anderson’s work in the Florida Passive Nitrogen Removal Project and is a hybrid of the two projects.

In order to finalize designs, two preliminary experiments with monitoring have occurred and involve the successive steps necessary for denitrification.

1. The nitrifying layer tests
2. The denitrification media tests.

Nitrifying in Cape Cod’s geological setting

In general, nitrification of household wastewater on Cape Cod faces a significant challenge. Assuming the presence of total nitrogen in wastewater of at least 40 mg/L, the required alkalinity (~280 mg/L) is generally not available (wastewater influent at the

Test Center approximates 18- mg/L). Many innovative/alternative septic systems in Barnstable County require augmentation of wastewater with a source of carbonate.

In this reporting period we have conducted experiments with a shallow drainfield to determine whether the generally-accepted assumptions might be true and prohibit the ability to nitrify wastewater in a single-pass mode. Using six shallow trenches, we have confirmed that full nitrification of nearly all of the influent nitrogen (including the organic fraction) can be achieved. We have collected the percolate from these six individually lined trenches and used this percolate for denitrification experiments detailed below.

In order to get an indication of the seasonal differences, we have reviewed data on this system for January-March 2014. In all cases, the maximum Total Kjeldahl Nitrogen (TKN) or ammonium was 1 mg/L. This surprising result suggests that complete nitrification within an 18” soil profile is possible and that winter temperatures only minimally affected this process.

There are two aspects of these trenches which may contribute to their ability to nitrify the wastewater to the extent observe. Foremost, the soil used in these trenches was a 60% sand – 40% silt mix. This soil retains moisture differently than standard “Title 5” sand or ASTM C-33. Secondly, the loading rate to the soil was 0.5 gal/sq. ft. /day based on the basal area of the shallow drainfield product used.

In order to isolate whether the soil was a determinant of the nitrification, we are presently constructing two side-by-side trenches; one having “Title 5” sand and the other with the 60% sand – 40% silt mix. These will be monitored for the extent of nitrification and the rate of achieving that nitrification.

Denitrification using a cellulosic material

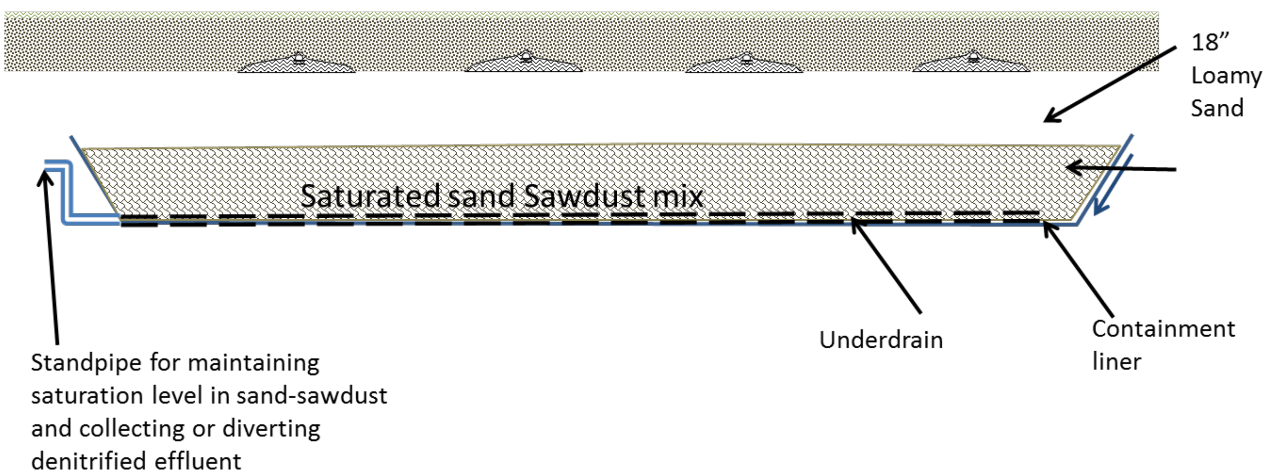
Discussion with Damann Anderson confirmed the Florida Project’s success with a 50% sand and 50% sawdust mix for the denitrification reactor media. Saturation is essential since the denitrification process is intolerant of even low (1 mg/L) oxygen. We have constructed and tested three columns that simulate the 18” of saturated reactor layer that is proposed for the layered system. The hydraulic loading rate of these columns was 0.5 gal/sq. ft. /day, similar to the hydraulic rate of the proposed overlying nitrification layer. The influent to these columns was being supplied by the previously-mentioned trenches by collecting the composited percolate and pumping it over the column in micro-doses of 100-150 ml.

In all cases, the nitrate in the influent (20-30 mg/L N) was reduced to levels below the detection limit of the analytical technique used (0.5 mg/L N). This level of removal suggests a larger scale trial of the technique. Accordingly, our next exercise will be to construct a large scale (330 gal/day system).

Preparation for large scale test

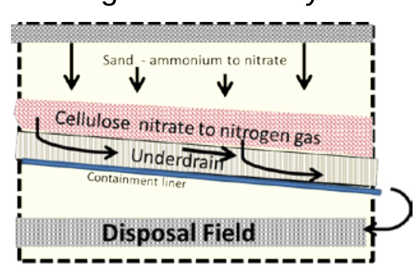
The first large-scale test will be situated in an existing lined cell area previously used for a soil-absorption system technology test. The lined “bathtub” will be emptied with the exception of one inch of ASTM C33 sand and the attendant cell drains. The area is approximately 15’ x 30' and equivalent to a two-bedroom flow. This area was chosen for convenience and readiness and will test three of the four “layer” of the completed system: the pressure distribution layer, the nitrification layer and the denitrification layer. The final disposal layer will not be tested in this experiment, but is planned for the final iteration of the passive denitrification system. The schema of the system is presented below.

Test cell with the two major components of the final design (missing is the final disposal which will be located beneath the containment liner.



The extent of denitrification will be measured at the discharge location of the standpipe. In the normal field installation, this location could be located in a manhole and piped to final disposal underneath the containment liner. This design is being dubbed a “layer cake” design with the successive layers:

Dispersal – Shallow drainfield
Nitrification Layer – Loamy sand
Denitrification Layer – Sand – Sawdust in saturation
Final Disposal -



Initial trial and small scale experiments will be completed by the end of July. Concurrently we will be constructing the large scale pilot.

.

Contact: George Heufelder, Director
Barnstable County Department of Health and Environment
gheufelder@barnstablecounty.org

Progress Report on the investigation of non-proprietary means of removing nitrogen in onsite septic systems

Barnstable County Department of Health and Environment
Massachusetts Alternative Septic System Test Center

July-August 2014

Background

The Barnstable County Department of Health and Environment (BCDHE) received funding from the Cape Cod Commission and from Massachusetts DEP (under the Section 319(b) Competitive Grant Program) to investigate means for the removal of nitrogen from wastewater in onsite septic systems using non-proprietary technology. The goal is to review information from publically-funded projects and published studies throughout the country and to determine the applicability of those findings to our area. The project seeks to integrate promising principles into simple designs for nutrient reducing systems that have low energy and relatively simple installation requirements. A major focus is the use and/or modification of soils-based treatment trains, although some efforts using modular containment units variously situated to work passively with soil components will also be investigated.

The major projects included under this investigation include the Florida Onsite Sewage Nitrogen Reduction Study (FOSNRS) (primary information source Damann Anderson with Hazen & Sawyer), work by Dr. Will D. Robertson (University of Waterloo), and a demonstration project conducted by Mr. John Eliasson, Wastewater Management Section, Division of Environmental Public Health Washington State Department of Health. In addition, this project benefits from the experience and knowledge of George Loomis, Dave Kalen and Dr. Jose Amador (University of Rhode Island , NE Onsite Wastewater Training Program) and Dave Potts (Geomatrix LLC) all of whom we have conferred with on many occasions.

Project Strategy

Following a review of the aforementioned projects and a discussion with the Principal Investigators and others, we have identified those aspects of the system designs that might have regional differences significant enough to preclude simple duplication of those project designs and installation in our area. Accordingly, a series of small scale experiments were conducted in order to inform designs for our geographical area. These experiments and initial results are described below.

Nitrification – the necessary precursor for denitrification

The first significant aspects of the nitrogen removal process that require regional verification are nitrification processes. Following ammonification in a septic tank (conversion of organic nitrogen to ammonia), the ammonia must be oxidized to nitrate. This is generally a two-step process carried out by ammonia-oxidizing bacteria. It is generally accepted that, in addition to the requirement for oxygen, alkalinity of the wastewater plays a key role in affecting ammonia oxidation. An estimated requirement for alkalinity is that each mg/L of ammonia-nitrogen requires ~7 mg/L of alkalinity (expressed calcium carbonate) for the oxidation to nitrate. Through discussion with Damann Anderson, we discover that wastewater in Florida generally exceeds this requirement. Wastewater in Barnstable County however generally contains insufficient alkalinity (150-200 mg/L) to allow for the oxidation of anticipated ammonia (40 – 60 mg/L).

In order to identify potential problems in this area, a series of 42 inch-diameter soil columns were constructed with four replicates of three different soil types: sand ("Title 5" sand), loamy sand (70% sand- 30% silt), and a sandy loam (60% sand-40%silt). Columns contained four feet of material beneath the point of wastewater dispersal and moisture sensors were placed at a depth of 24' and 30-1/2" beneath the point of wastewater dispersal. Each column was individually drained to a separate percolate collection point. Hydraulic loading rate to all soil types was 0.7 gal/sq. ft. /day (2.9 cm/day), chosen for its intermediate rate between prescribed rates for those soils in Massachusetts.

Summary of Results – Column studies.

Column studies of three soil types confirm that near complete nitrification is possible, despite theoretical limitations of alkalinity. Nearly complete nitrification of all ammonium occurred in all soil types (figs 1 – 3).

To determine the rate-limiting potential for alkalinity, a one-time alkalinity measurement was taken in the percolate from each of the soil columns on August 19, 2014. Unexpectedly, the alkalinity in the sand columns indicated a high potential for limiting any further nitrification (replicates included non-detectable alkalinity, 2.0 mg/L, 2.9 mg/L and 3.6 mg/L), while the sandy loam and loamy sand all had remaining alkalinity exceeding 200 mg/L. This level is generally near equivalent to the influent alkalinity.

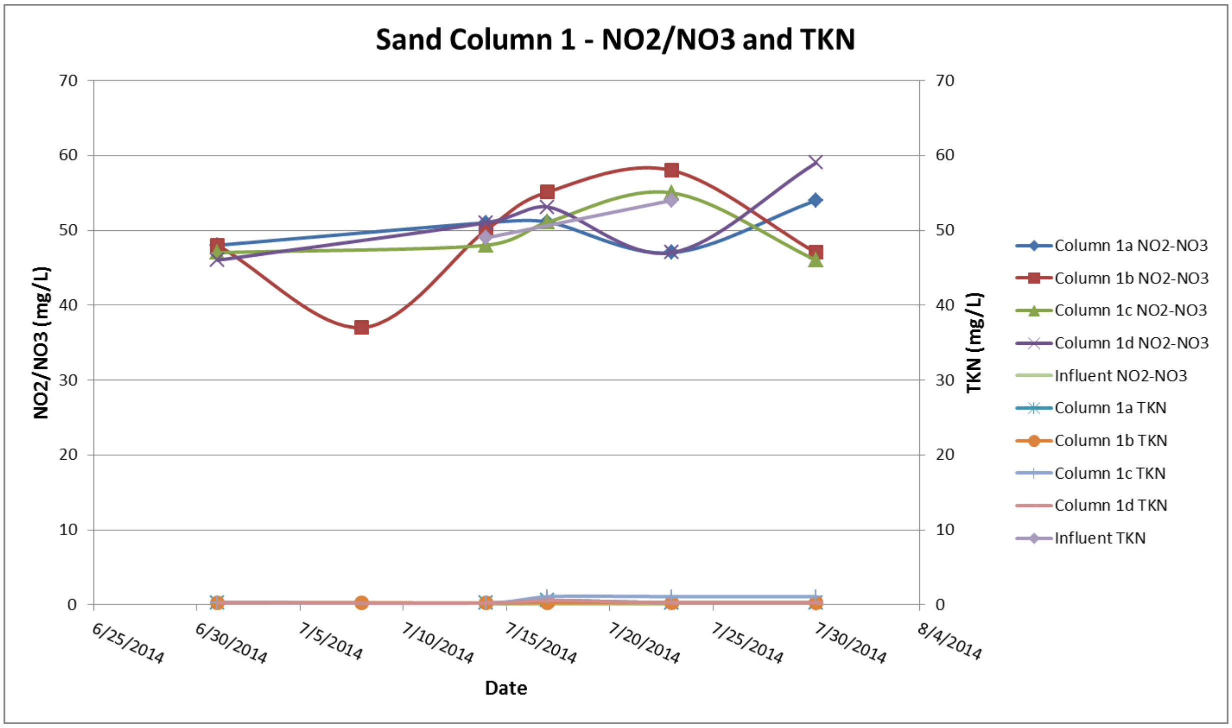


Figure 1. Nitrate-nitrite and TKN levels in percolate from Sand Column 1 (four replicates).

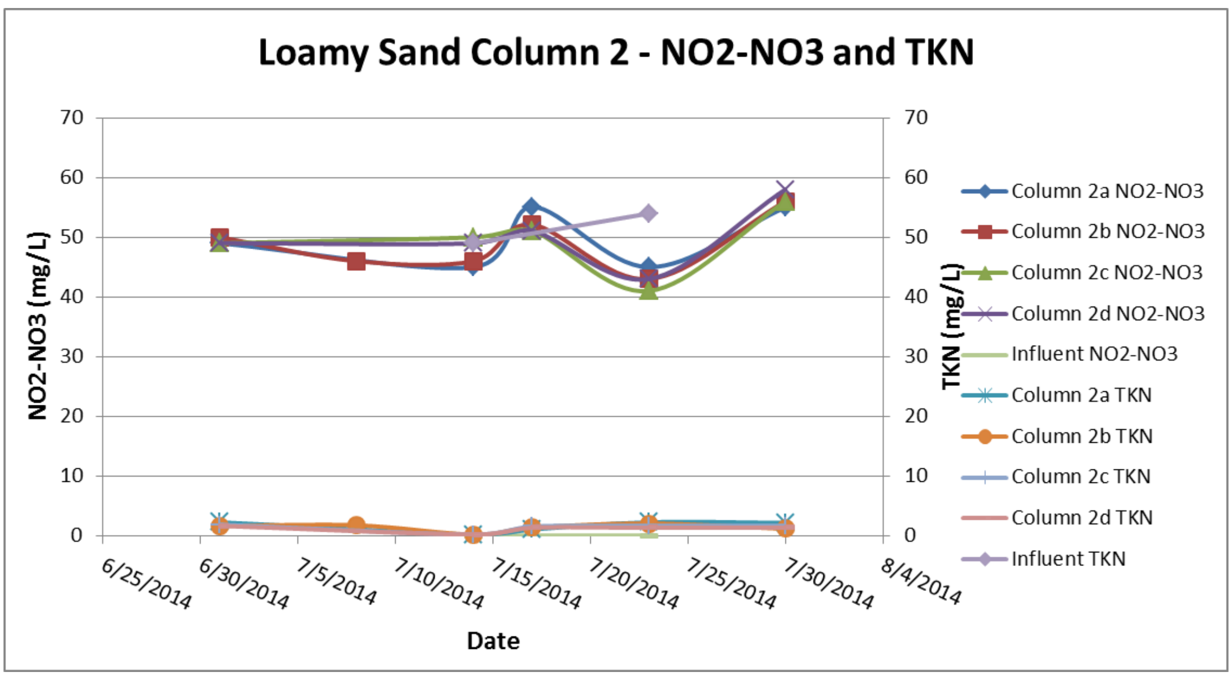


Figure 2. Nitrate-nitrite and TKN levels in percolate from Loamy Sand Column 2 (four replicates)

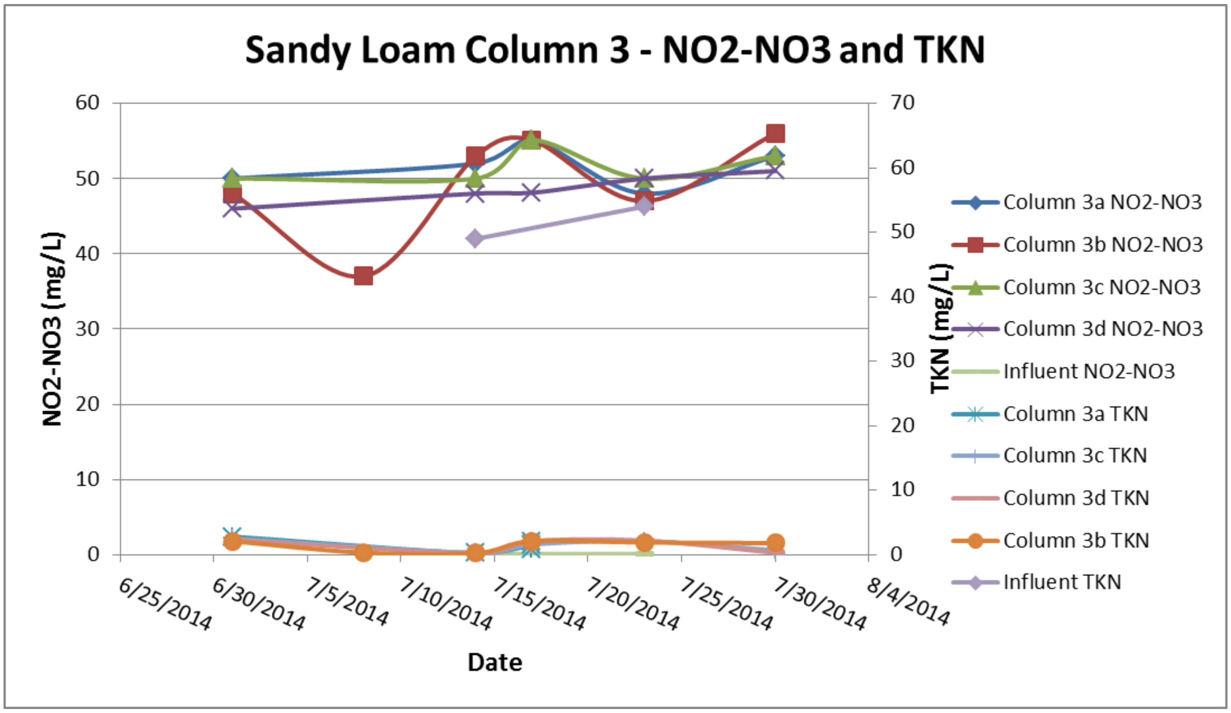


Figure 3. Nitrate-nitrite and TKN levels in percolate from Sandy Loam Column 3 (four replicates)

The reason for the high remaining alkalinity of the loamy material is not clearly understood and may be the result of mineral differences between the sand (obtained from a local distributor on Cape Cod) and the loamy material (obtained from a specialty soil distributor in Leominster, MA). The results do concur however with other observations over the past four years indicating near-complete nitrification of wastewater within passage of 18 inches of loamy sand, again despite the theoretical deficiency of alkalinity.

Also in contrast with the conventional understanding of nitrification chemistry are the pH levels which were expected to decline during nitrification but remained relatively stable in the experiments conducted. The sand column nitrification depressed pH more than the loamier material (figure 4), however all of the column pH levels could support nitrification.

These data suggest that, despite theoretical deficiencies in alkalinity, all soils studied have the potential for complete nitrification within 4 ft. of soil passage. Further work suggests that the loamier material may be capable of supporting nitrification within 18 inches of soil passage. In the case of the loamier soils tested, the alkalinity of the percolate suggest the capacity for nitrification of higher levels of ammonia, while the sand appears to present a limiting condition for any further nitrification.

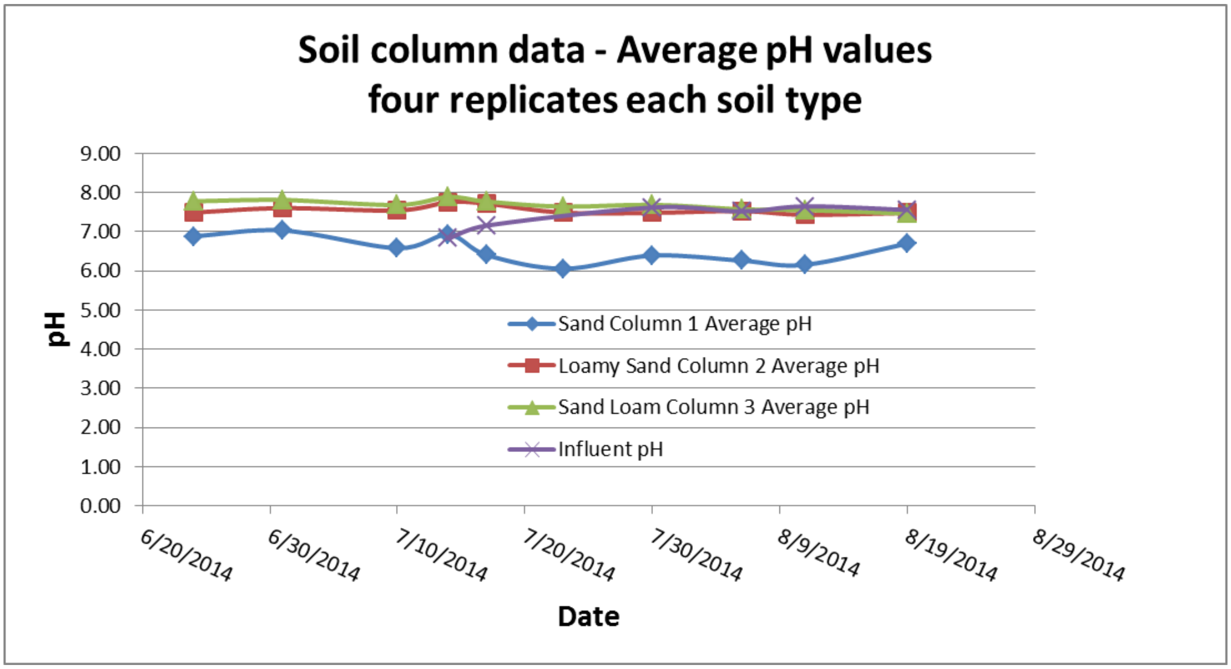


Figure 4. Average pH levels from percolate from soil columns (4 replicates each) and influent wastewater.

Denitrification using cellulosic material

The denitrification process requires an oxidized form of nitrogen (nitrite-nitrate), organic carbon for the denitrifying bacteria and anoxic conditions. To achieve these conditions, each of the projects investigated have used a cellulosic material (generally woodchips or sawdust), situated in the treatment sequence following the nitrification step. The FOSNRS work layered a mix of sand with sawdust (50%-50% by volume) beneath a nitrifying layer of 18 inches of sand. In that study, the wastewater was distributed to the nitrifying layer using a drip dispersal system. The sand-sawdust mix was situated atop an impervious liner and the percolate (having passed through the upper sand nitrifying layer and the sawdust-sand mix layer) was diverted by the impervious liner to a drain leading to the dispersal area[1]. The concept is schematically shown below (figure 5).

In order to test this component of the system, two series of soil columns (18” diameter x 18” deep) were constructed. The vertical dimension was derived from the FOSNRS. The first series of three test columns were to simulate a completely saturated condition. Each column was filled to a depth of 18 inches of a 50%-50% sand-sawdust mix in a totally saturated condition (figure 6).

[1] In the FOSNR design there is an ability to convey the wastewater percolate through a sulfur upflow filter which is not detailed here for simplification of the discussion.

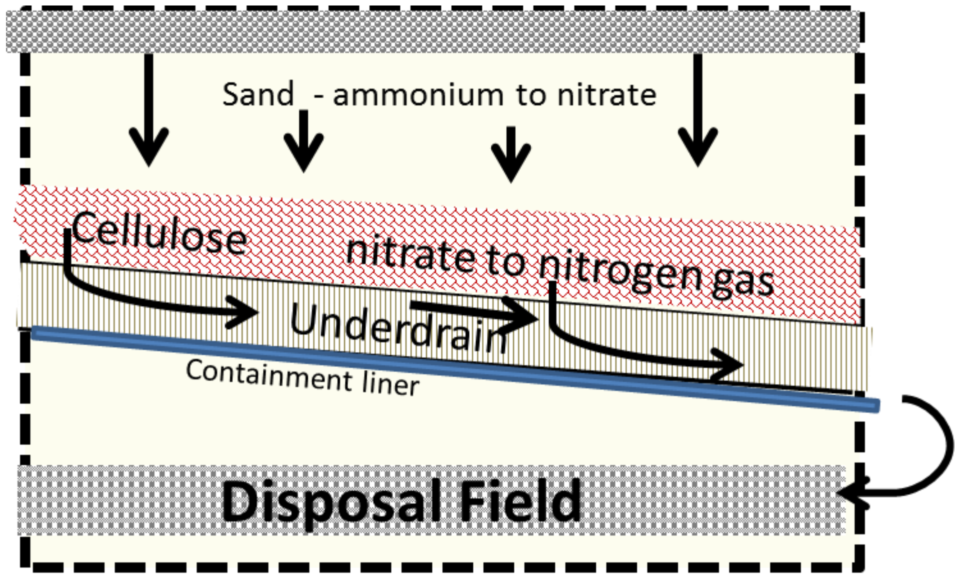


Figure 5. Schemata of the "layer" configuration similar to the FOSNR program.

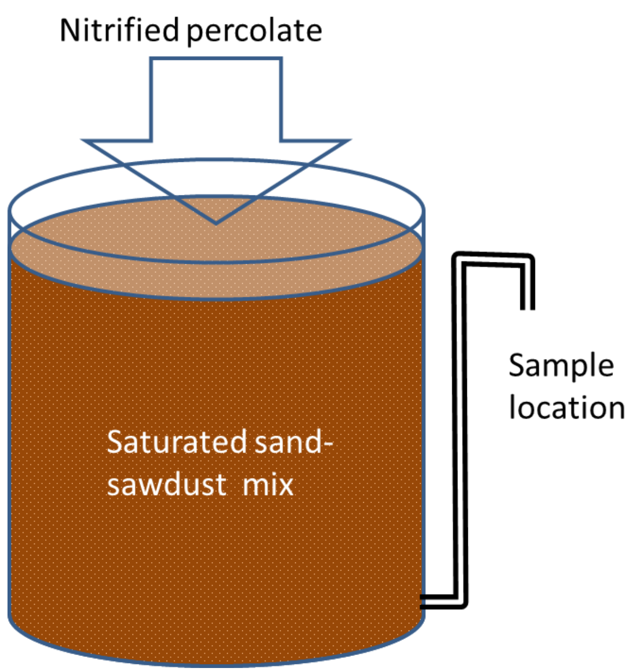


Figure 6. Schemata of a test series of saturated flow of nitrified percolate through a 50%-50% sand-sawdust mixture.

The nitrified percolate was obtained from a shallow soil distribution system previously constructed and in operation since 2011 which was collected and dispersed to the columns. That system is configured with 18" of loamy sand. The hydraulic loading rate was 0.5 gal/ sq. ft. /day (2 cm/day) to both the shallow drainfield and the soil column and was controlled by small dosing pumps. The results suggest a significant reduction in nitrate (figure 7).

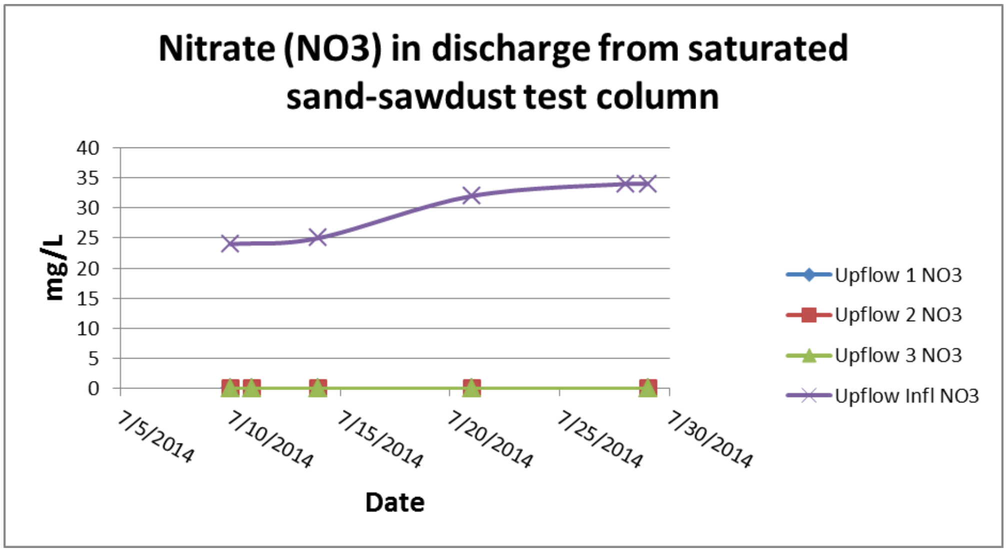


Figure 7. Nitrate reduction following 18 inches of nitrified percolate passage through 18 inches of saturated 50%-50% sand-sawdust column. Influent was derived from a shallow drainfield as described.

Interestingly, initially TKN values were higher than the influent nitrified effluent, but appear to diminish over time, with resulting total nitrogen levels below 5 mg/L (figure 8).

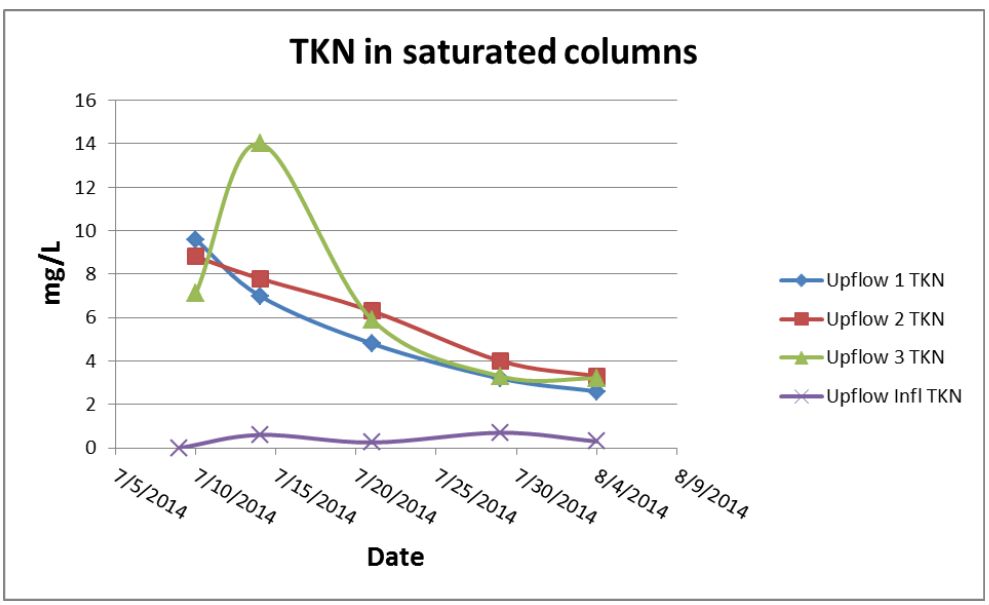


Figure 8. TKN reduction following 18 inches of nitrified percolate passage through 18 inches of saturated 50%-50% sand-sawdust column.

While conducting the saturated column experiments, it was realized that the positioning of a nitrifying soil layer directly above a fully saturated layer may create a capillary fringe in the nitrifying layer that would be counterproductive to nitrification. Discussions with Damann Anderson had revealed that in the FOSNRS study, complete saturation of sand-sawdust mix may not be necessary. Accordingly, three additional soil columns were constructed to simulate unsaturated conditions above a liner (figure 9). These columns were again 18 inches in depth and diameter, the depth mimicking the FOSNRS work. The columns were supplied nitrified effluent from the same source as the saturated columns.

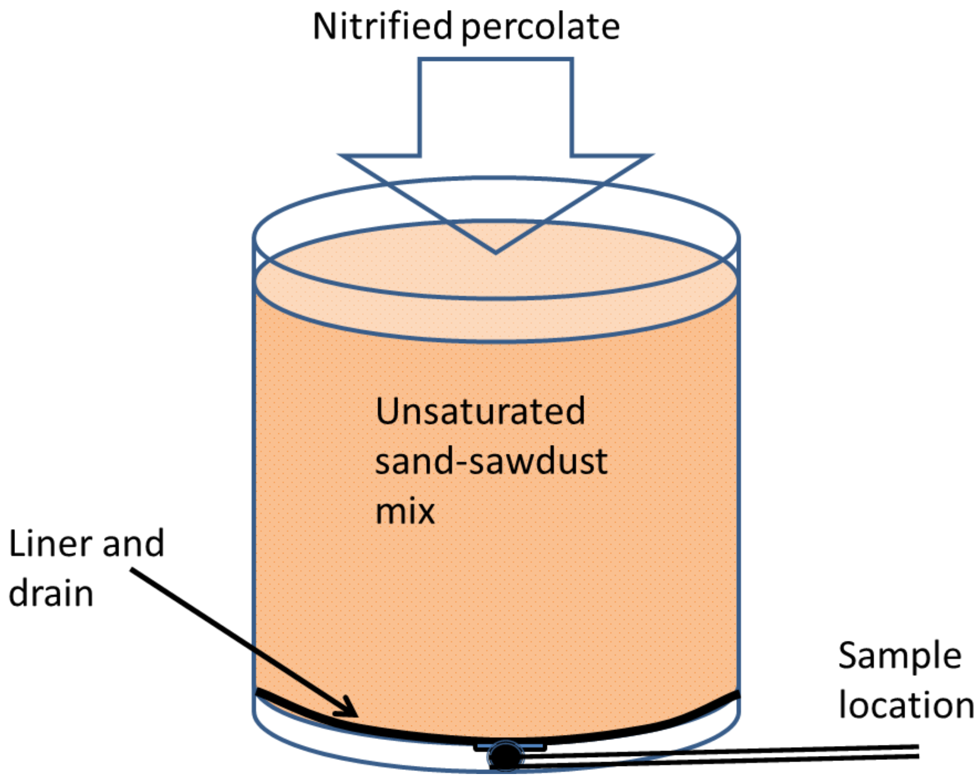


Figure 9. Schemata of a test series of unsaturated flow of nitrified percolate through a 50%-50% sand-sawdust mixture.

Following the start-up of the unsaturated columns on July 26, 2014, initial samples on July 28 indicated a near complete breakthrough of nitrate unchanged (figure 10). At that time oxygen concentration measurement in the soil indicated relatively high 15% - 18% oxygen and very little carbon dioxide. However by August 4, 2014 nitrate was not detected in the percolate. Measurements of oxygen showed that all three soil columns had < 10% concentration of oxygen in the soil air space.

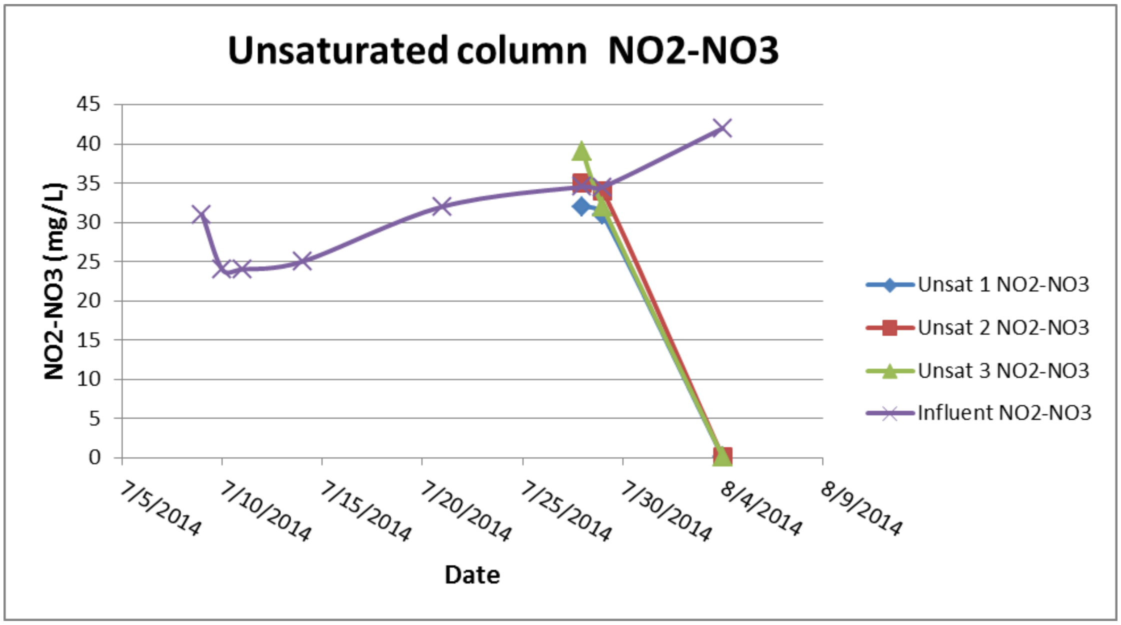


Figure 9. Nitrate reduction following 18 inches of nitrified percolate passage through 18 inches of unsaturated 50%-50% sand-sawdust column.

Similar to the saturated columns, initially high TKN levels were also reduced between the July and August sampling of the unsaturated columns. Resulting nitrogen concentrations were < 4 mg/L.

Conclusions and Next steps

If confirmed, these results suggest that complete nitrification of wastewater in native or an available soil is possible. The operation of the shallow drainfield providing the nitrified percolate shows that nitrification can be achieved within an 18-inch soil profile. Coupled with the observed reduction in nitrified percolate nitrogen to levels < 5 mg/L in a layer of sand mixed with cellulosic material (sawdust) within an 18-inch vertical profile suggest that a layered system with a 36-inch profile may be an effective denitrification component. A draft concept schema for an installation in our area is presented in figure 10. Similar to the FOSNRS, the component assumptions must be further confirmed.

Foremost, it should be understood that all of the experiments have taken place at ambient summer temperatures. Temperature is a prime determinant of the rate for biological processes. Since ammonification, nitrification and denitrification are all biological processes, we must confirm the rates of reaction through the winter months to determine the range of reaction rates in a natural setting.

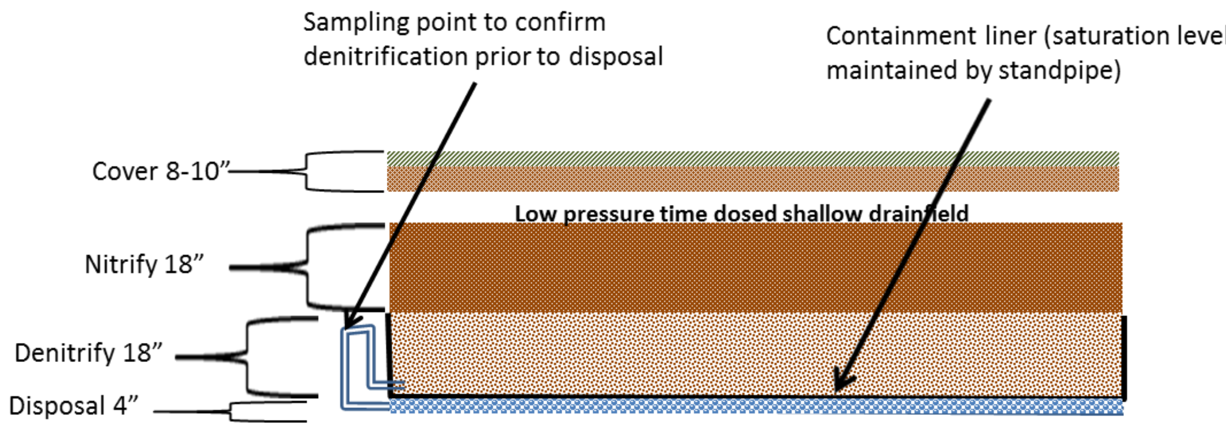


Figure 10. Concept schemata of denitrification system using a layered approach.

The tasks to be completed in the next work period include:

- Verification of nitrification and denitrification processes through winter months;
- Increased measurements for BOD in cellulosic material discharge to anticipate issues with final disposal;
- Construction of additional soil columns or a small scale system that integrates the nitrification and denitrification process and conduct sampling;
- Continue discussion of data and information with collaborators, and;.
- Continue to analyze Florida results for possible modifying information.

Summary

Our initial results suggest the possibility that the incorporation of wood material as a carbon source for denitrification within the soil treatment unit of a septic system may be viable. There are many components of the strategy that must be confirmed and were discussed. Temperature, a prime determinant of reaction rates will be investigated this winter season.

.

Contact: George Heufelder, Director
Barnstable County Department of Health and Environment
gheufelder@barnstablecounty.org

Progress Report on the investigation of non-proprietary means of removing nitrogen in onsite septic systems

Barnstable County Department of Health and Environment
Massachusetts Alternative Septic System Test Center

October - December 2014

Background [review]

The Barnstable County Department of Health and Environment (BCDHE) received funding from the Cape Cod Commission and from Massachusetts DEP (under the Section 319(b) Competitive Grant Program) to investigate means for the removal of nitrogen from wastewater in onsite septic systems using non-proprietary technology. The goal is to review information from publically-funded projects and published studies throughout the country and to determine the applicability of those findings to our area. The project seeks to integrate promising principles into simple designs for nutrient reducing systems that have low energy and relatively simple installation requirements. A major focus is the use and/or modification of soils-based treatment trains, although some efforts using modular containment units variously situated to work passively with soil components will also be investigated.

The major projects included under this investigation include the Florida Onsite Sewage Nitrogen Reduction Study (FOSNRS) (primary information source Damann Anderson with Hazen & Sawyer), work by Dr. Will D. Robertson (University of Waterloo), and a demonstration project conducted by Mr. John Eliasson, Wastewater Management Section, Division of Environmental Public Health Washington State Department of Health. In addition, this project benefits from the experience and knowledge of George Loomis, Dave Kalen and Dr. Jose Amador (University of Rhode Island , NE Onsite Wastewater Training Program) and Dave Potts (Geomatrix LLC) all of whom we have conferred with on many occasions.

Project Strategy [review]

Following a review of the aforementioned projects and a discussion with the Principal Investigators and others, we have identified those aspects of the system designs that might have regional differences significant enough to preclude simple duplication of those project designs and installation in our area. Accordingly, a series of small scale experiments were conducted in order to inform designs for our geographical area. These experiments and results are described below.

Nitrification – the necessary precursor for denitrification [new data]

The first significant aspects of the nitrogen removal process that require regional verification are nitrification processes. Following ammonification in a septic tank (conversion of organic nitrogen to ammonia), the ammonia must be oxidized to nitrate. This is generally a two-step process carried out by ammonia-oxidizing bacteria. It is generally accepted that, in addition to the requirement for oxygen, alkalinity of the wastewater plays a key role in affecting ammonia oxidation. An estimated requirement for alkalinity is that each mg/L of ammonia-nitrogen requires ~7 mg/L of alkalinity (expressed calcium carbonate) for the oxidation to nitrate. Through discussion with Damann Anderson, we discover that wastewater in Florida generally exceeds this requirement. Wastewater in Barnstable County however generally contains insufficient alkalinity (150-200 mg/L) to allow for the oxidation of anticipated ammonia (40 – 60 mg/L).

In order to identify potential problems in this area, a series of 42 inch-diameter soil columns were constructed with four replicates of three different soil types: sand (“Title 5” sand), loamy sand (70% sand - 30% silt), and a loamier sand (60% sand - 40%silt). Columns contained four feet of material beneath the point of wastewater dispersal and moisture sensors were placed at a depth of 24’ and 30-1/2” beneath the point of wastewater dispersal. Each column was individually drained to a separate percolate collection point. Hydraulic loading rate to all soil types was 0.7 gal/sq. ft. /day (2.9 cm/day), chosen for its intermediate rate between prescribed rates for those soils in Massachusetts, however during this study period, we modified the loading rate to one of the replicates (designated “D” in each of the three soil types tested) in order to determine whether increased hydraulic loading rate affected the total nitrogen removal or the process of nitrification.

Summary of Results – Column studies.

Column studies of three soil types continued to confirm that near complete nitrification is possible, despite theoretical limitations of alkalinity. Nearly complete nitrification of all ammonium occurred in all soil types that received the initial hydraulic loading (figs 1 – 3).

To determine the rate-limiting potential for alkalinity, measurement of the percolate from each of the soil columns was conducted routinely following August 2014. The alkalinity in the sand columns indicated a high potential for limiting any further nitrification (all measurements indicate < 6 mg/l alkalinity) while percolate from the remaining soil types all exceeded 200 mg/L. This level is generally near equivalent to the influent alkalinity.

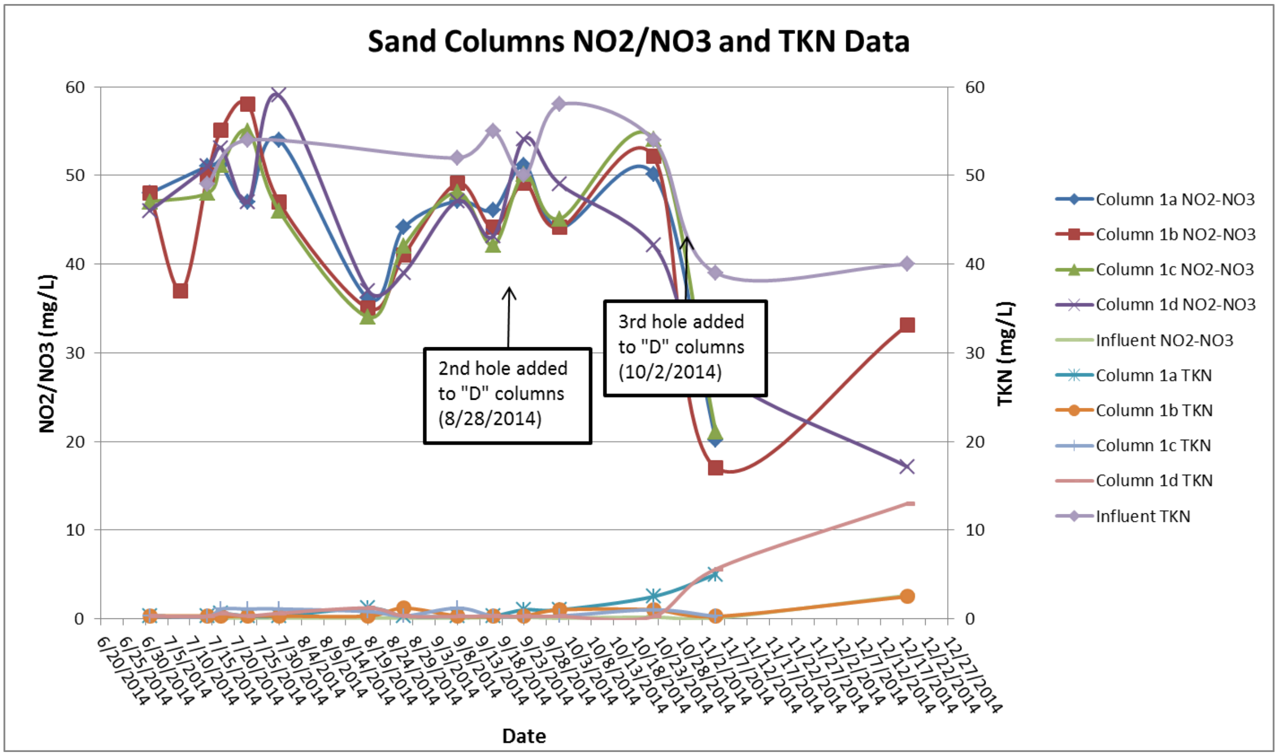


Figure 1. Nitrate-nitrite and TKN levels in percolate from Sand Column 1 (four replicates).

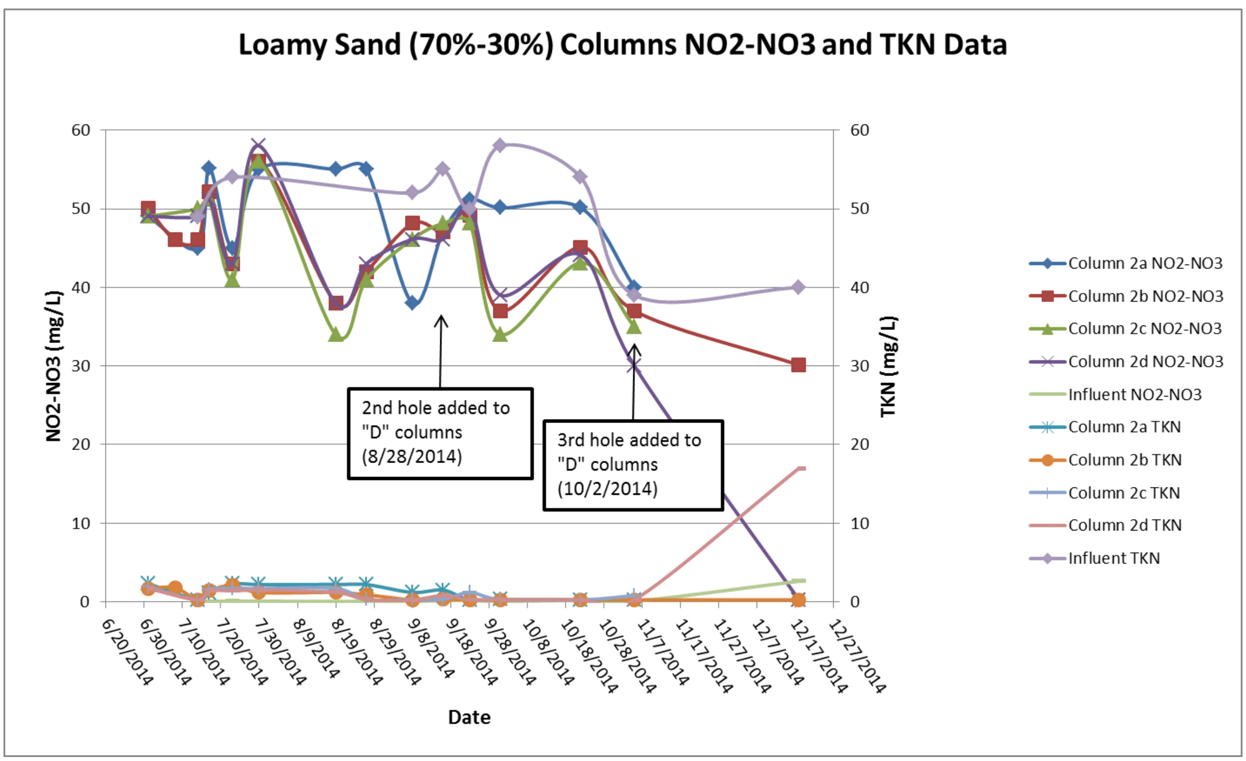


Figure 2. Nitrate-nitrite and TKN levels in percolate from Loamy Sand Column 2 (four replicates)

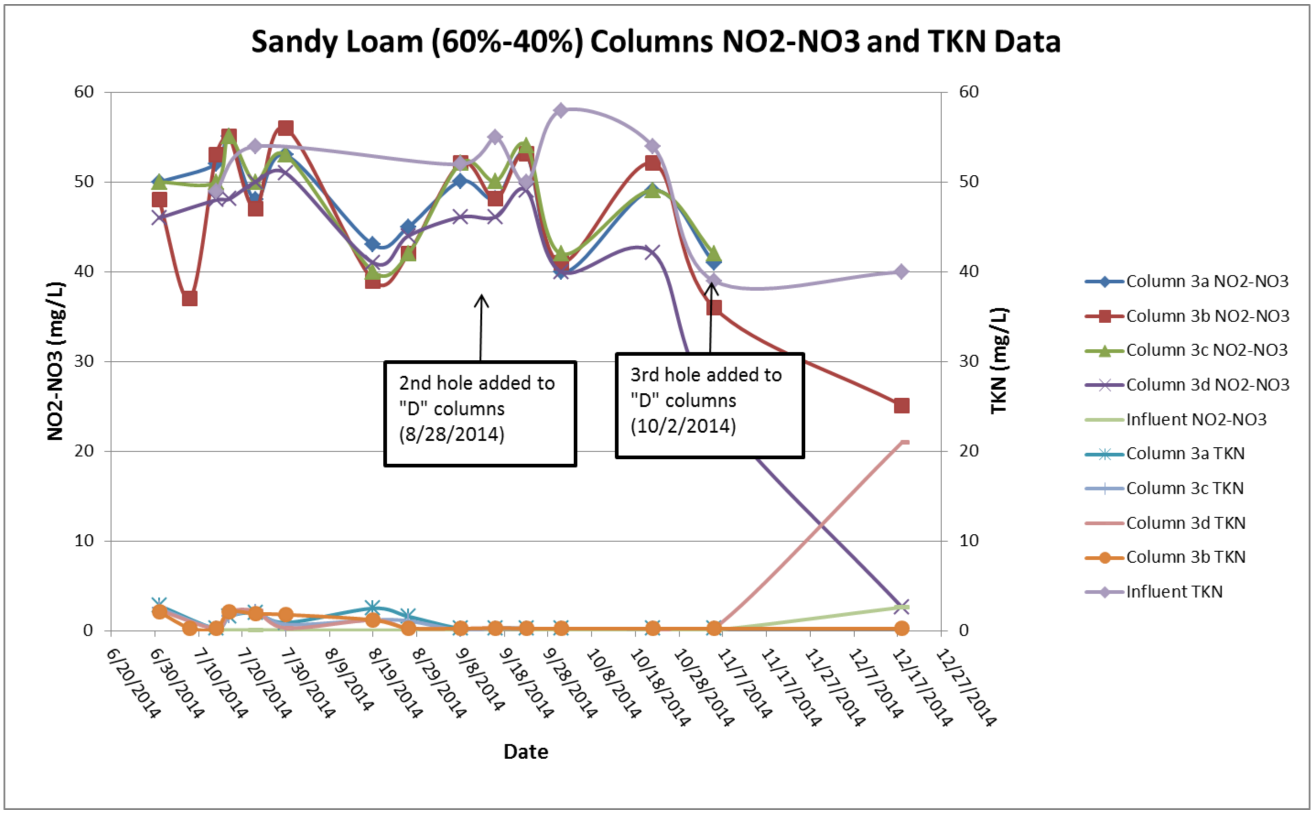


Figure 3. Nitrate-nitrite and TKN levels in percolate from Sandy Loam Column 3 (four replicates)

The reason for the high remaining alkalinity of the loamy material remains unclear and may be the result of mineral differences between the sand (obtained from a local distributor on Cape Cod) and the loamy material (obtained from a specialty soil distributor in Leominster, MA). The results do concur however with other observations over the past four years indicating near-complete nitrification of wastewater within passage of 18 inches of loamy sand, again despite the theoretical deficiency of alkalinity of the influent wastewater.

Also in contrast with the conventional understanding of nitrification chemistry are the pH levels which were expected to decline during nitrification but remained relatively stable in the loamy sand. The sand column nitrification depressed pH more than the loamier material (figure 4) however all of the column pH levels supported nitrification as evidenced by the nitrate/TKN data.

These data suggest that, despite theoretical deficiencies in alkalinity and accepted wisdom regarding pH requirements and limits on nitrification, all soils studied have the potential for complete nitrification within 4 ft. of soil passage. Further work suggests that the loamier material may be capable of supporting nitrification within 18 inches of soil passage. In the case of the loamier soils tested, the alkalinity of the percolate suggest the capacity for nitrification of higher levels of ammonia, while the sand appears to present a limiting condition for any further nitrification with very low levels remaining following percolation.

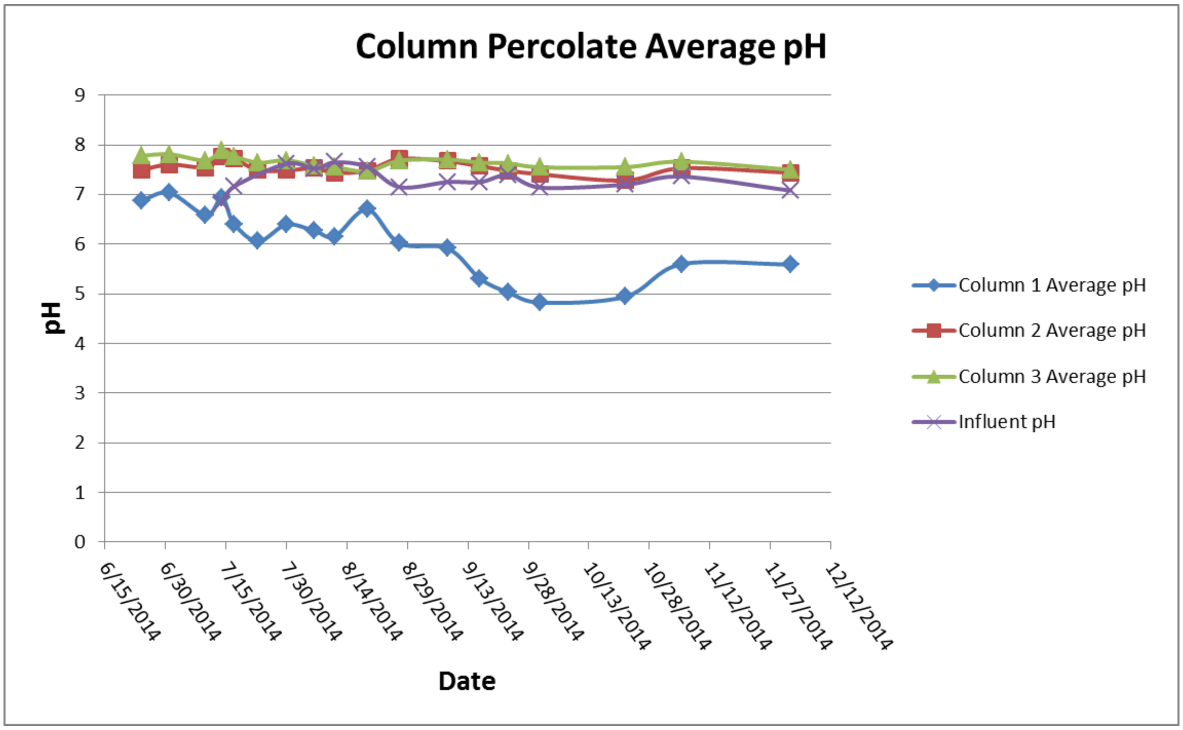


Figure 4. Average pH levels from percolate from soil columns (4 replicates each) and influent wastewater.

From August through December, the hydraulic loading in one replicate of each soil type was increased as a means of possibly encouraging more anoxic conditions conducive to coincident nitrification-denitrification. The increased loading (2X from August 28 to November 2nd and 3X from November 2nd to December 23rd) had different effects depending on soil types. For the sand soil, there was a decrease in the overall nitrification, however the total nitrogen compared with the same sand receiving the 1X loading rate exhibited 5 mg/L less total nitrogen compared with the 3X loaded cell. For the 70%-30% loamy sand this effect was more profound, with the 3X loaded cell exhibiting >12 mg/L concentration of total nitrogen compared with the 1X loaded cell. Finally, the 60%-40% mixture sand showed < 2 mg/L difference between the 1X and 3X loaded cell.

These data suggest in a preliminary way the ability to optimize the removal of nitrogen by modifying the soil type and loading rate. Since only one date of samples was available at this reporting, later sample-data will be presented and analyzed in a future report.

Denitrification using cellulosic material

The denitrification process requires an oxidized form of nitrogen (nitrite-nitrate), organic carbon for the denitrifying bacteria and anoxic conditions. To achieve these conditions, each of the projects investigated have used a cellulosic material (generally woodchips or sawdust), situated in the treatment sequence following the nitrification step. The concept is schematically shown in previous reports.

[review]

The two series of soil columns (24” diameter x 18” deep) reported on previously were periodically monitored during this reporting period and continued to show promise for the removal of nitrate-nitrogen. The reader will recall that one series of columns contained a saturated 50%sand/50% sawdust mix (figure 5) and the other contained an unsaturated mix of the same material (figure 6). Each was supplied nitrified (containing primarily nitrate) percolate from an existing drainfield.

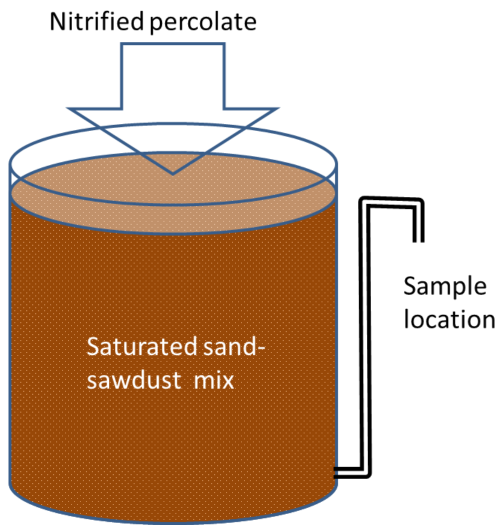


Figure 6. Schemata of a test series of saturated flow of nitrified percolate through a 50%-50% sand-sawdust mixture.

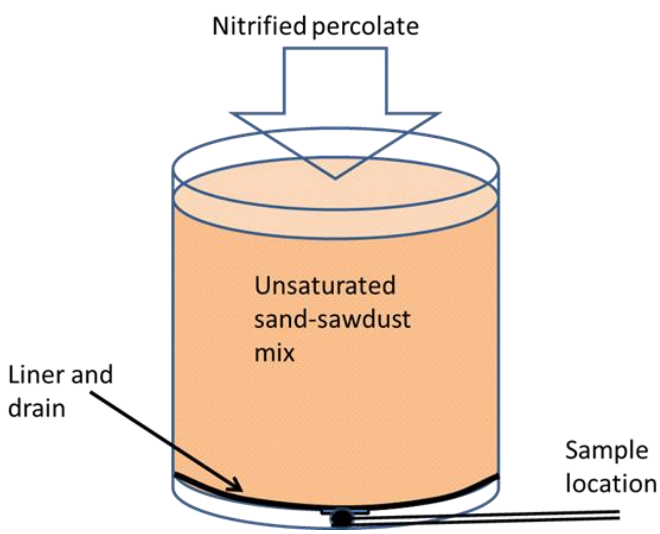


Figure 7. Schemata of a test series of unsaturated flow of nitrified percolate through a 50%-50% sand-sawdust mixture.

Total nitrogen values following passage through the saturated column of sawdust-sand mixture continued to show removal of nitrogen down to levels < 5.0 mg/L (figure 8).

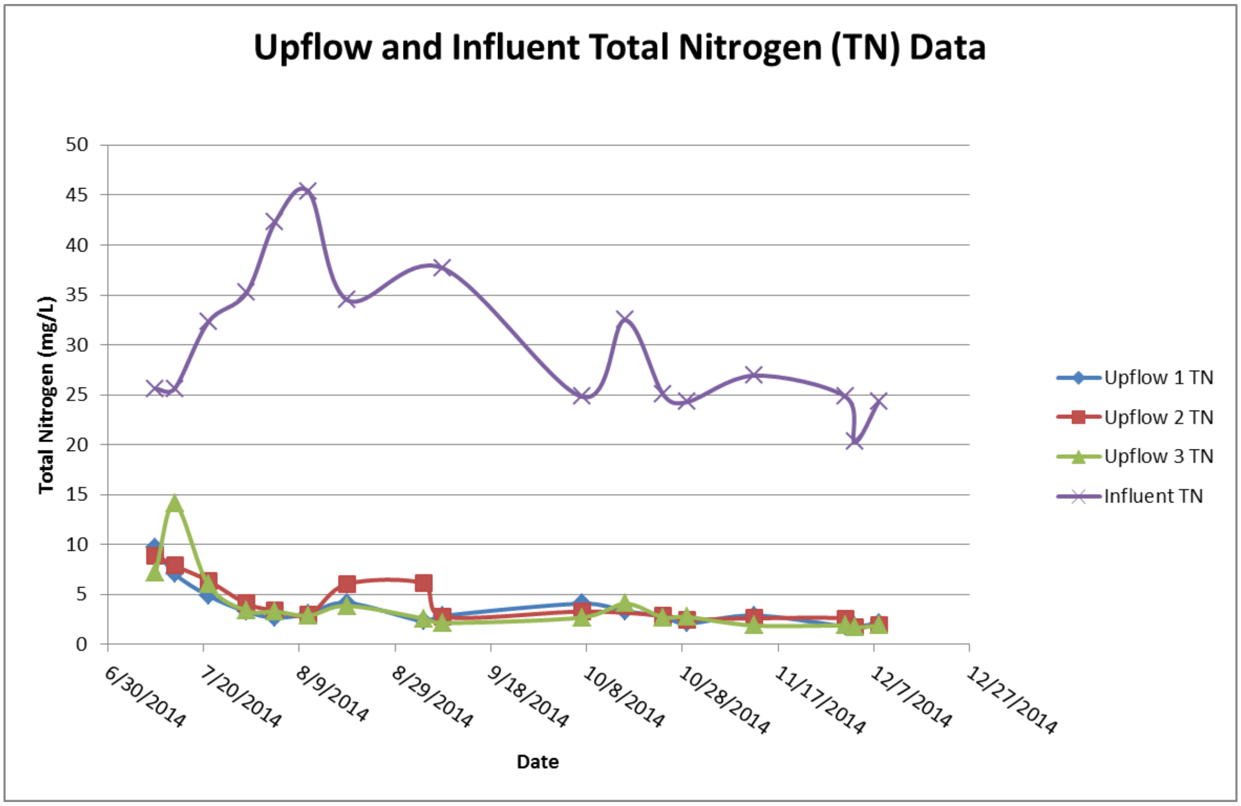


Figure 8. Nitrate reduction following passage through 18 inches of saturated 50%-50% sand-sawdust column. Influent was derived from a shallow drainfield as described.

Similar to the saturated columns, the nitrate removal from nitrified effluent passing through the unsaturated columns of sawdust-sand removed total nitrogen to levels generally < 5 mg/L for the study period (figure 9), but unconfirmed results suggest an increase in nitrate levels in later testing. These later values will be discussed in a future report.

Putting it all together – Layer Cake 1

The reader recalls that the previous experiments used nitrified percolate from an existing pressure-dosed leachfield which was dosed to the top of the soil columns. We next constructed the entire soil profile for a small-scale trial. The conceptual drawing is below (figure 10). This was constructed within a containment area of approximately 25 sq. ft., and supplied with septic tank effluent. Hence, in small scale, the entire profile was simulated.

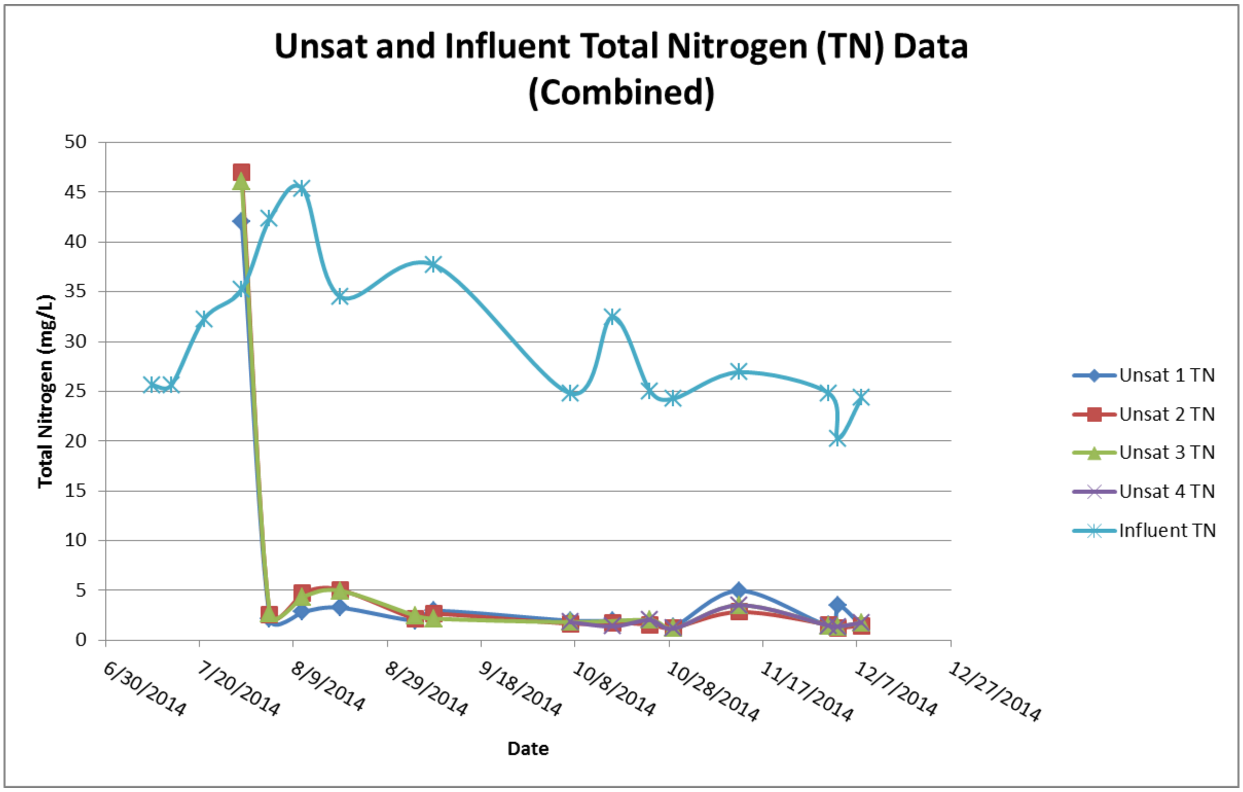


Figure 9. Nitrate reduction following 18 inches of nitrified percolate passage through 18 inches of unsaturated 50%-50% sand-sawdust column.

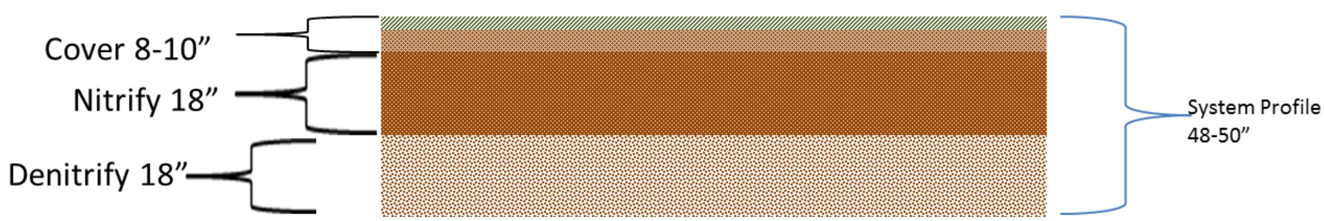


Figure 10. Concept schemata of denitrification system using a layered approach.

The system was constructed in late October and first sampled November 3, 2014. Early and low total nitrogen levels in the percolate through the system are likely due to luxury uptake by wastewater organisms (figs 11 & 12). Climbing levels in late November are the result of a spike in nitrate levels as nitrifying bacterial populations increased, moderated by apparent treatment and removal of some nitrate in the sand-sawdust layer of the system by denitrifying bacteria. These preliminary results are promising, however the soil column work and tentative later results (showing climbing nitrate levels as yet however not confirmed), temper any further conclusions.

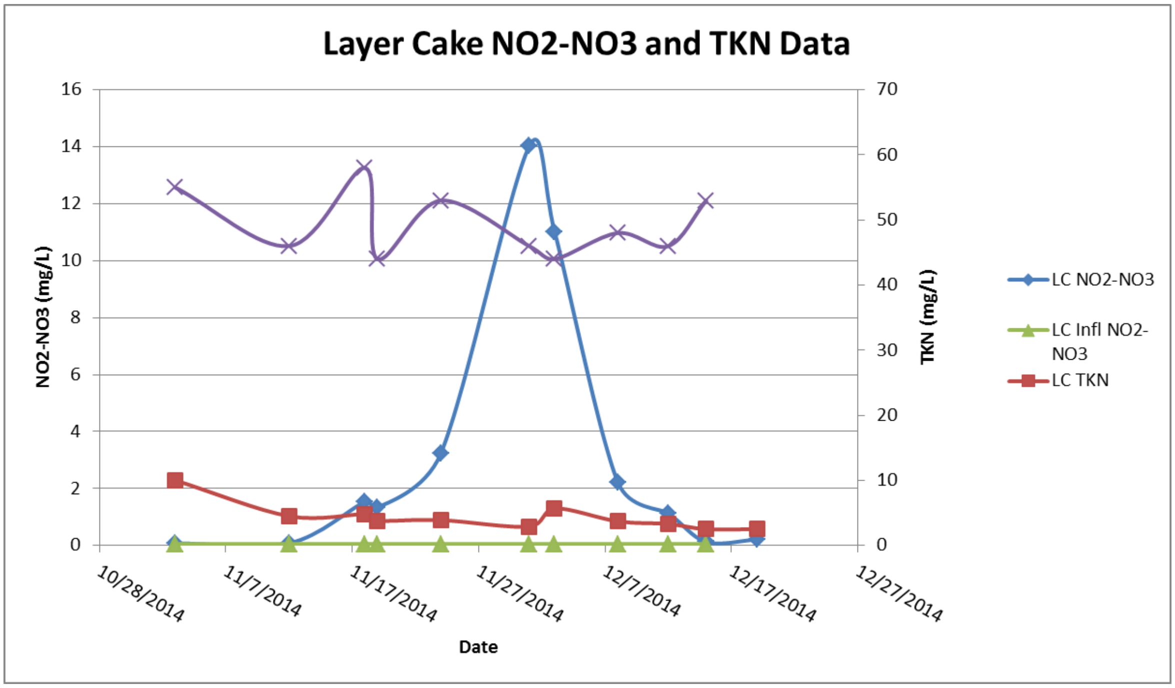


Figure 11. Nitrogen species in percolate of small scale layered system receiving septic tank effluent and containing an unsaturated 18" layer of sawdust-sand beneath 18" layer of loamy sand. Purple line = TKN of influent.

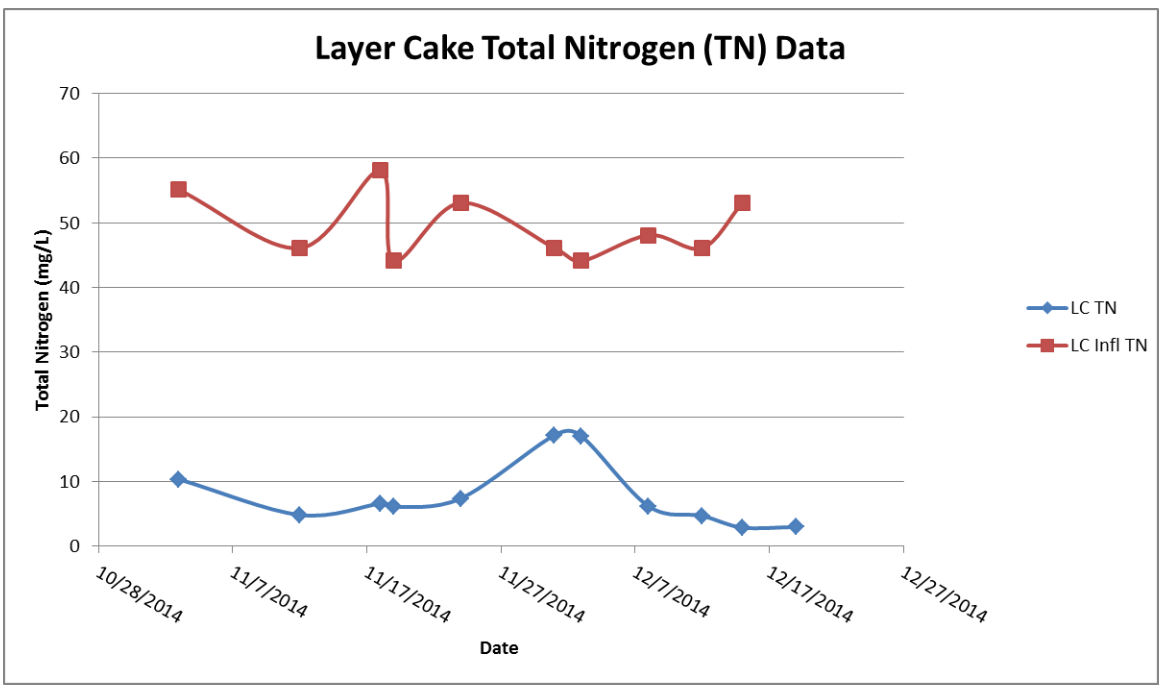


Figure 12. Nitrogen species in percolate of small scale layered system receiving septic tank effluent and containing an unsaturated 18" layer of sawdust-sand beneath 18" layer of loamy sand.

Putting it together in large scale

Finally, during this period we have constructed a 15' x 30' full-profile system adaptable for a saturated denitrifying layer. The concept is illustrated below (figure 13). This system began construction in December and was recently completed and started. The system is receiving raw wastewater to a septic tank, which flows by gravity to a pump chamber. A system of lateral distribution pipes feeds the septic tank effluent to the top of the layered system. No results are available thus far.

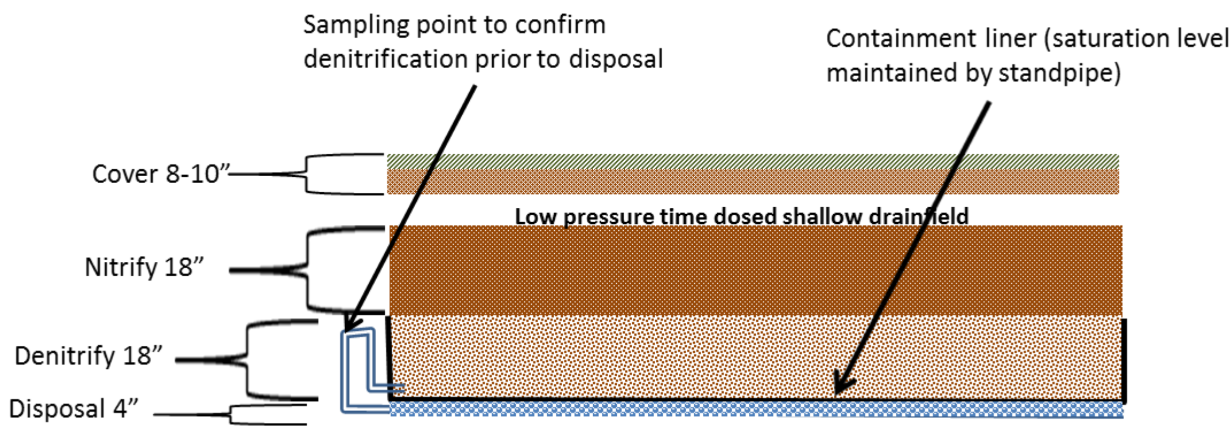


Figure 13. Concept schemata of large scale denitrification system using a layered approach. Final disposal in this system is a return to the wastewater treatment plant

Summary

Our results continue to suggest the efficacy of the incorporation of wood material as a carbon source for denitrification within the soil treatment unit of a septic system. We will continue to confirm the results

.

Contact: George Heufelder, Director
Barnstable County Department of Health and Environment
gheufelder@barnstablecounty.org

BARNSTABLE COUNTY DEPARTMENT OF HEALTH

PROGRESS REPORT FOR THE PERIOD OF OCTOBER 16, 2013 – DECEMBER 31, 2013

INVESTIGATION OF NON-PROPRIETARY ONSITE SEPTIC SYSTEM STRATEGIES FOR REMOVAL OF NITROGEN

This project endeavors to takes advantage of findings from three publically-financed projects and a collective of soils-based research efforts to determine the efficacy of non-proprietary soils-based strategies for nitrogen removal. The first months of the project have been used to research and determine design criteria for the project trials. Four generic design standards are being reviewed for relevancy to our geographic area. The "Florida Passive Design" is being reviewed for feasibility of construction as well as adjustments to be made for our area. This design has been installed at full-scale for the first time in spring-summer 2013 in Florida and we are working with Damann Anderson (Hazen and Sawyer) to determine features and components that require modification for our area. A draft design for installation at the Massachusetts Alternative Septic System Test Center (MASSTC), operated by The Barnstable County Department of Health and Environment, is expected by mid-February. The second design being investigated was part of efforts near the Waquoit Bay Estuarine Research Reserve (WBNERR) as part of a National Demonstration Project in the mid-1990s. We have been in contact with the origin of the intellectual property for design as well as the contractor who installed that system. A location for its installation at MASSTC has been determined and the design for a pilot installation is anticipated in mid-February. We are presently researching the Falmouth Board of Health files for construction detail. The third design strategy propagates from design work done in conjunction with research funded by the Canadian Water Network Nova Scotia Environment and the Natural Sciences and Engineering Research Council by Dr. Robert Jameson, Dalhousie University, Halifax, Nova Scotia. We are presently determining critical design criteria that will allow feasible use in our geographical area to enhance the nitrogen. The final design type being investigated is the shallow drainfield. This design is being referenced in the **Recommendations of the On-Site Wastewater Treatment Systems Nitrogen Reduction Technology Expert Review Panel** for the Chesapeake Bay Area and is being assigned a nitrogen removal credit. We are presently compiling a design in conjunction with George Loomis and Jose Amador, Ph.D., University of Rhode Island. The design will be finalized in mid-February, 2014 with anticipated installation as MASSTC in March. Two soil types and two variants of low-pressure distribution will be installed and tested.

Coincident with design work is the analysis of data from all soils-based system work as MASSTC to determine whether these data can inform decisions for design in the present project. This analysis has yielded information regarding the effect of pretreatment on nitrogen reduction in soils that is being prepared for presentation.

Progress Report on the investigation of non-proprietary means of removing nitrogen in onsite septic systems

Barnstable County Department of Health and Environment
Massachusetts Alternative Septic System Test Center

March 2014

Background

In October, 2013 the Barnstable County Department of Health and Environment (BCDHE) received funding from the Cape Cod Commission to investigate means for the removal of nitrogen from wastewater in onsite septic systems. The focus of these investigations was the identification and testing of technology enhancements to septic systems for the removal of nitrogen that are public domain (non-proprietary). Due to its operation of the Massachusetts Alternative Septic System Test Center, BCDHE was to install and test promising candidate technologies using the most appropriate standardized protocol(s) during spring 2014.

During the time period October 2013 – March 2014, investigations suggested five sources of information and/or designs with promise. These are listed below accompanied by activities conducted and focused on refining the candidate list for testing.

The Florida Passive Nitrogen Removal Project

The State of Florida has allocated significant resources toward investigating “passive” methods for nitrogen removal in onsite septic systems. Passive, by this project’s definition allows the use of one non-aerating pump.

In close consultation with Damann Anderson (Hazen and Sawyer, Environmental Engineers and Scientists), one of the project’s lead investigators, we obtained site plans and engineering drawings of the first full-sized residential system based on a prototype. For this project, we will install and test the best design to date at the Massachusetts Alternative Septic System Test Center (MASSTC) while maintaining the flexibility to alter operational parameters as the Florida results develop. Herein, this design is referred to as the “Florida design”. The following modifications to the design are being considered.

- The Florida design used a drip dispersal mechanism for distributing septic tank effluent (STE) over a bed of sand having a depth of 18”. Studies at MASSTC suggest that full nitrification (a prerequisite for denitrification) of STE requires only 6 – 12 inches of sand. The shallower vertical profile and the use of a more generic low-pressure distribution system should translate to less cost (fill and construction and possibly maintenance).

- A stage 2 biofilter denitrification tank (1050 gallon) was specified in the pilot design. This tank was filled with elemental sulfur in order to further reduce nitrate (through bacteria that oxidize elemental sulfur while reducing the nitrate to nitrogen gas). Although we will install the tank, we are proposing to pipe through the structure until initial data are gathered. This strategy will maintain the flexibility to use this design component at a later date should it be necessary.

The goal in replicating this design is to determine the applicability in our geographic area. This design has a drip dispersal field for "water reclamation" which in that context is the irrigation of a lawn area, however again this would add expense and maintenance. We will be investigating the possibility of constructing the final disposal area *beneath* the reactor bed as a strategy to reduce the footprint and possibly save on excavation costs (this was done at one site in Florida). This may be possible since our use of only 8 – 10 inches of sand in the nitrifying layer allowed for some saving of vertical profile.

Our next efforts in this project will be to carefully examine all MASSTC data to determine the minimal vertical profile of the nitrifying layer to determine whether these data better inform the final design of this feature.

The Waquoit Bay National Estuarine Research Reserve (WBNERR) Design

The WBNEER design actually originates from the work of Dr. Will Robertson from the University of Waterloo. In this design a horizontal layer of silt-sand-woodchips is constructed below a denitrifying area bed.

We have had a correspondence with Dr. Robertson and he believes that the strategy is worth pursuing. He believed that the design proliferation may be restricted by the availability of the silty soil mix necessary to maintain strata saturation above a water table. We have been investigating various sources of material and are presently looking to New England Specialty Soils as a possible source for consistent mix of soil.

At present we have a bid for the construction of a system at MASSTC by the contractor who installed the original WBNEER design. A location at MASSTC has been designated and we are completing the design for delivering wastewater to the reactor bed. In the absence of a refined specification for the soil in the wood-soil mixture, the contractor believes that he can reasonably duplicate the system that was installed in 1996 in Waquoit at MASSTC using available materials.

Shallow-Narrow Drainfields

There was initial indication that shallow drainfields, situated in the vertical profile and situated in finer-textured soils might result in significant (>50%) removal of nitrogen. In the process of investigating this possibility, on February 19, 2014 the staff met with the following individuals listed below. These individuals are technology reviewers from the State of Rhode Island and have extensive knowledge of both soils-based treatment and shallow-horizon systems.

February 19, 2014 Meeting at University of Rhode Island with...

José A. Amador, Professor
Associate Editor, Tropical Ecology
Laboratory of Soil Ecology and Microbiology
024 Coastal Institute - Kingston
University of Rhode Island
Kingston, RI 02881 USA
Voice: 401 874 2902 | FAX: 401 874 4561
E-mail: jamador@uri.edu
Web: https://sites.google.com/site/soilecologyandmicrobiology/home

George Loomis and Dave Kalen
Research and Extension Soil Scientist
Director, New England Onsite Wastewater Training Center
NRS Dept. 1 Greenhouse Rd.
University of Rhode Island
Kingston, RI 02881
401-874-4558 fax -4561
http://www.uri.edu/ce/wq/OWT/index.htm

David Potts
Environmental Scientist

Geomatrix, LLC
114 Mill Rock Road East
Old Saybrook, CT 06475
860-510-0730 - phone
860-510-0735 - fax
860-227-0636 - cell
www.geomatrixsystems.com
www.soilair.com

The purpose of the discussion was to work toward an optimum design for the shallow drainfields that are to be installed at the Test Center to quantify the extent of denitrification of wastewater. A number of design modifications were discussed. One design that seemed the most promising provides impervious collection structure(s) beneath the drain lines of a shallow drainfield that diverts a portion of the flow back to the septic tank (in effect a recirculating in-ground sand filter) with various configurations showing that return flow through a woodchip component. It was agreed however that the standard design of a shallow drainfield would not provide more than approximately 40% TN removal. It was also agreed that any forward flow from recirculating systems that allowed nitrified effluent to bypass the final denitrification carbon source might limit the denitrification. Accordingly, this strategy remains in the further-investigation-needed status before final designs are completed.

Nova Scotia Design

The "Nova Scotia" design follows upon a number of works published by Dr. Rob Jamieson, PhD, P.eng, Associated Professor and Canada Research Chair in Cold Regions Engineering, Environmental Engineering Program, Dalhousie University and others. These works suggested that denitrification can be achieved by a horizontal filter type design modified from the original designs published. Discussions with Dr. Jamieson indicated that he had some further unpublished research and some ideas on optimizing nitrogen removal using a contour trench design, but as yet we have not finalized designs or decided that this option is to be pursued.

Washington State Efforts

In late December 2013, staff became aware of the efforts of Washington State to test three "public domain" technologies. Of these three technologies one in particular appears to hold promise for economical nitrogen removal and is being considered for installation and testing. Staff has conferred with one principle investigator and has reviewed concerns regarding design features that might be modified to maintain denitrification in the New England climate.

Sampling Protocol

There are three sampling protocols for the purpose of documenting nutrient reduction being considered. The Environmental Technology Initiative (ETI) protocol was first initiated by MASSTC in 1999 and involved the installation of three replicates of each technology sampled bi-weekly for two years. Concurrent to the initial trial of the ETI protocol, MASSTC performed a number of tests using a 12-14 month protocol developed jointly by the National Sanitation Foundation (NSF) and the Environmental Protection Agency (EPA) and referred to as the Environmental Technology Verification (ETV) protocol. Finally, in response to input from various stakeholders (vendors, users and regulators), NSF developed the Standard 245 Protocol. Comparison of features is allowed by the following summary table.

ETI (1999-2002)	ETV (2001-)	NSF STD 245 (2007-)
24 months duration 3 systems Biweekly testing No stress tests See what you get with 156 data points	14 months duration 1 system Monthly testing + daily 5x after stresses Stress tests See what you get with 50-60 data points	6 months duration 1 system Testing 3x/week + daily 5x after stresses Stress tests Must achieve 50% reduction to pass

It has been argued by many that a protocol of only six-month duration (NSF STD 245) may not allow for performance review during colder months, since theoretically if the test was started in early spring it would be completed by the colder winter months. Accordingly, a number of technology vendors completing the STD 245 at MASSTC have remained for the duration equal to the ETV test. This has complicated the stress test schedule of the ETV test since these are all of the same stresses of the SDT 245 and had been completed by the six-month end of that test. This was, therefore, not in strict adherence to the ETV test.

These facts being considered, we have decided to follow the ETV Protocol similar to the work and efforts of The University of Washington, Civil and Environmental Engineering Department and Washington State Department of Health, Office of Shellfish and Water Protection in their recent report on three non-proprietary technologies. This protocol aligns with the majority of informal discussions with northern-states regulators who feel that a one-year protocol is minimal and that there is value to stress testing. In addition to influent/effluent testing called for in the ETV Protocol, intermediate (following the nitrification elements of the systems) will also be periodically tested to inform design changes.

Contact: George Heufelder, Director
Barnstable County Department of Health and Environment
gheufelder@barnstablecounty.org