Report as of FY2009 for 2008TN52B: "Effect of Wastewater Strength on Soil Physical Properties when using Subsurface Drip Irrigation"

Publications

- Dissertations:
    - Hillenbrand, Boone,2010,An Investigation for the Need of Secondary Treatment of Residential Wastewater when Applied with a Subsurface Drip Irrigation System,"MS Dissertation", Department of Biosystems Engineering and Soil Science, Insitute of Agriculture, the University of Tennessee, Knoxville, TN.,pp 164.

Report Follows

(6) Nature, Scope and Objectives of Research:

The specific objectives of this project were to:

a) Determine whether biomat forms around drip tubing, and to determine whether the quality of the wastewater influences biomat formation around drip tubing.
b) Determine the extent of soil moisture saturation (if any) around the drip tubing.
c) Determine the renovation of the water at various depths below the point of application.
d) Determine the reduction in nutrients, and organic carbon as water moves through the soil.
e) Publish the new information generated by this project.

(7) Methodology and Accomplishments to Date:

Experimental Setup

A consistent supply of primary and secondary treated domestic wastewater was required for this project. Jackson Bend subdivision, located in Blount County, Tennessee, has a decentralized wastewater management system. Wastewater from each home is collected by a Septic Tank Effluent Pump (STEP) system that transfers effluent to a recirculating media filter for secondary treatment. The highly renovated effluent is then subsurface applied using drip irrigation. This location allowed the P.I to collect primary treated water out of the STEP system and collect secondary treated water out of the recirculating sand filter. Two separate subsurface wastewater drip dispersal fields were established. Each field has 305 m of subsurface drip line. Each drip field is composed of 10 parallel rows that are 15.24 m long. The drip lines were plowed-in 0.6 m on center. Specifications for drip line include pressure-compensated emitters rated at approximately 2.27 L/h with the emitters spaced every 0.6 m along the tubing. One drip field received septic tank effluent (primary treatment) and the second field received secondary quality effluent.

Approximately 1,514 L of domestic wastewater per day is applied each day. This includes 757 L of septic tank effluent and 757 L of secondary quality effluent. The dispersal field is 372 m^2, and thus the application rate was 4 $L/m^2/d$.

Data Collection

As of this writing, four rounds of samples have been collected from the experimental location. With Tennessee Water Resources Research Center Program funding, a graduate student was employed to conduct sampling and analyses. Two-inch diameter soil cores were extracted from selected locations within each field. The soil solution from these cores was analyzed for total organic carbon (TOC), total nitrogen, and total phosphorus. A second set of soil cores were extracted and evaluated for saturated hydraulic conductivity.

Soil core samples were taken at two depths, 0.3 and 0.6 m below the drip emitter elevation. Six sets of cores were pulled. Core 1 was at a emitter, core 2 was along the drip tubing, but between emitters, core 3 was at the emitter but between the drip lines (to the right in the direction of flow), core 4 was at the emitter but between the drip lines (to the left in the direction of flow), core 5 was both between emitters and between the drip tubing to the right, and core 6 was between the emitters and tubing to the left. As controls, two cores with samples from 0.3 and 0.6 m were taken from the native soil outside of the drip dispersal area. This procedure was repeated in both fields: The field receiving primary quality effluent and the field receiving secondary quality effluent.

The goal of the chemical analysis was not to extract all of the carbon, nitrogen and phosphorus out of the sample. Rather, this was an attempt to simulate saturated soil conditions and determine the constituent concentration that would be expected to percolate through to the groundwater. Soil chemical properties were analyzed by drying and then grinding the soil sample. Thirty grams of dry soil was mixed with 20 g of tap water and placed on a shaker table for 24 hours. This mixture was then centrifuged for 10 minutes at 3,500 rpm. A sample of the supernatant was extracted and subjected to chemical analyses.

Data Analysis
All of these samples will be analyzed to look for differences in soil solution quality and water movement as the two types of effluent pass through the soil profile. The null hypothesis is that the soil will be able to renovate and move the septic tank effluent equally well as the secondary-treated effluent. Statistical analysis was performed on the data to verify this hypothesis.

(8) Principal Findings and Significance:
The Jackson Bend site has been in operation since June 19, 2006. In that time, just over 6,000 L of effluent per m^2 has been applied. No significant differences have been found in the data concerning the concentrations of total nitrogen, nitrate-nitrogen, and total carbon from the two fields. There does appear to be a difference in saturated hydraulic conductivity.

The hydraulic conductivity differences at Jackson Bend with the primary and secondary treatments were not significantly different however the secondary side did have a significantly lower Ksat than the control. The estimated Ksat values for primary, secondary, and the control are as follows: 0.041, 0.036, and 0.073 cm/day respectively. The Ksat differences for 1-ft and 2-ft depths were not significant (0.049 and 0.050 cm/day respectively).

Jackson Bend shows no significance for nitrate with the primary, secondary, and control treatments. Depth was a significant factor for nitrate concentration with the concentration getting higher nearer the emitter (3.970 mg/kg at 1-ft and 2.602 mg/kg at 2-ft).

The concentration of total carbon for the primary treatment was lower than with the secondary and control treatments but not significant due to the variability in the data. This is counter-intuitive because one would expect there to be significantly more carbon on the primary side. It is speculated that uniform effluent application, and dose and resting cycles allowed by the drip irrigation promoted enhanced organic carbon degradation.

The total nitrogen concentration was not significantly different between the 3 treatments. The treatment means ranged from 6.4 to 8.4 mg/kg. The control at the 1-ft depth has a significantly higher concentration of TN than at the 2-ft depth but these concentrations are not significantly different than the primary and secondary samples at either depth.

The overall treatment differences in TP were not significantly different but there were differences when the trt*depth interactions are examined. The control samples at the 1-ft depth are significantly higher than the primary and secondary samples. The means for secondary are higher than the means for primary but are not significant.

(9) Summary and Conclusions:

The purpose of this study was to evaluate two strengths of wastewater (primary and secondary) being applied by subsurface drip dispersal to determine the need for secondary treatment. The purpose was not to evaluate the performance of subsurface drip dispersal as a whole. The soil has a tremendous ability to treat wastewater but its full potential may be retarded by the use of a costly secondary treatment. Physical and chemical properties of the soil were measured to make the comparison. It was found that the pore water in the soil that had been irrigated with the low strength wastewater was of slightly higher quality than the pore water in the primary treated side. At Jackson Bend, the hydraulic conductivity of the primary side show significant reduction as compared to the secondary and control areas; and within reason, this is beneficial for the treatment of the wastewater – more contact time with the soil. Nitrate and total nitrogen were significantly higher in the primary treated areas but showed a decrease with depth. TC and TP showed no significant differences. The benefits of a secondary treatment are not enough to make it necessary when using subsurface drip dispersal. The soil acts much the same as the secondary wastewater treatment plant and drip irrigation is designed to fully utilize these characteristics.

(10) Publications from this Effort

This work has produced a Master's Thesis. "An Investigation for the Need of Secondary Treatment of Residential Wastewater when applied with a Subsurface Drip Irrigation System" was written by Boone Hillenbrand for the partial fulfillment of the requirement of a M.S. degree in Biosystems Engineering. Boone graduated in August of 2010.