Lab 4. Soil Water

This week's lab will take place at the Cornell University Turfgrass Field Research Laboratory and Robert Trent Jones Golf Course. At the Turfgrass Research Laboratory, we will conduct one percolation test as a group. Then we will take infiltration measurements at the turf plots. These plots have different soil textures, which will affect their infiltration rates. In the second part of the lab, we will take infiltration and surface runoff measurements on the golf course.

Your task will be to access the suitability of a site for a septic system and to access whether soil management has maintained good infiltration rates.

Objectives

- Examine the effects of soil texture, structure and compaction on water infiltration
- Measure the impact of soil compaction on surface runoff
- Distinguish between soil infiltration and percolation and identify important soil properties that impact these processes
- Perform a percolation test for septic systems

Reading

- 5.6 Infiltration and Percolation
- 6.8 Percolation and Groundwater
- 6.9 Enhancing Soil Drainage
- 6.10 Septic System Drain Fields

Site Background

The Turfgrass Field Research Laboratory is comprised of twenty-eight acres of turfgrass field research and borders the No. 8 fairway of the Robert Trent Jones Golf Course at Cornell University. This site established in 1973 and has seen consistent growth and development. Researchers are investigating environmental, soil, and turfgrass management issues on 120 mini-greens that represent a portion of the Turfgrass Field Research Laboratory. Additional facilities include an equipment repair shop, storage barn, and a state-of-the-art pesticide management facility, which is shared jointly by the Turfgrass Field Research Laboratory and the Robert Trent Jones Golf Course. An in-ground irrigation system, controlled by a new Toro LTC central/satellite system, irrigates one-third of the field research laboratory. The remaining land area can be irrigated by means of temporary above ground solid-set system supplied by strategically located hydrants. Irrigation water, which is supplied by a nearby creek, is pumped into a quarter-acre holding pond at the research laboratory and then pumped put to the irrigation system. Native soil types range from sandy loams to silty clay loams.

The 18-hole University Golf Course, the front nine of which was completed in 1954 with funds contributed by alumni, is a championship course designed by the noted golf architect Robert Trent Jones (Cornell '30). The back nine layout (between Warren Road and Pleasant Grove Road) was the university's first nine holes and has been in use since 1941.

Urban Soils

Until now the labs have focused on soils as a natural component of the rural environment. We also need to consider high-use urban and suburban landscapes. The soils will have many similar characteristics to agricultural and forested lands. However, they also have unique management needs, in large part due to their greater exposure to human influences. Even more than agricultural lands, the physical and chemical alteration of urban soils results in degradation of structure, resulting in loss of macropores, surface crusting, and restricted aeration and drainage, as well as contamination from toxins. While these problems tend to be associated with urban/suburban environments, they can be found in any area that receives a high degree of human traffic, such as camping and picnic areas, hiking trails, and parks.

The maintenance of soil structure is particularly important in the management of urban and high-use soils. Conditions in urban setting that contribute to soil structural degradation include transportation or displacement of soil, lack of vegetative cover, low organic matter, altered wet-dry and freeze-thaw cycles, and unremitting traffic.

Infiltration and Percolation

A well-structure "healthy" soil, containing earthworm castings and root channels, will have more continuous macropores connected to the surface, contributing to rapid infiltration of water, than a compacted soil with scarce vegetation. Soil compaction crushes macropores, which in turn reduces infiltration. A slower infiltration rates increases the probability of surface runoff. In addition, the force of runoff water accelerates erosion during intense rainfall events. Water infiltration into soil is also influenced by soil texture and surface characteristics. A heavy textured with few large pores such as clay would have a slower infiltration rate that a sandy soil. Soils that have no vegetative cover are vulnerable to forming surface crust. The lack of surface pores in a crusted soil diminishes vertical infiltration of water, resulting in surface water runoff.

When water does infiltrate the surface, macropores fill and water begins to move downward and laterally through the profile in a process called percolation. Percolation involves both saturated and unsaturated flow. An abrupt change in pore size, such as from a fine-textured soil to an underlying coarse textured soil, will influence the percolation process by altering the rate of water movement. Examples of abrupt changes in soil structure and texture include natural horizons such as fragipans or man-made modifications resulting from grading.

Under unsaturated conditions, macropores are filled with air and water movement occurs through finer micropores. Under saturated conditions, water movement occurs by gravity flow through macropores. Sandy soils generally have higher macropore space compared to clayey soils and thus have a higher rate of saturated flow.

The importance of saturated and unsaturated flow rates in soil is not confined to managing soils to optimize plant growth. Water movement through soil is also an important consideration for waste disposal. For instance, rural homeowners who are not served by a city's sewage system have to install a septic system to dispose of household wastewater. Before installing a septic system, a soil scientist has to assess the suitability of the residence's soil for handling wastewater. This assessment is done with a percolation or perc test. A perc test measures the permeability of the soil. The test requires digging a hole of approximately 12 inches by 12 inches, which is then pre-soaked from several hours up to a day. After the soil is sufficiently saturated, water is added to the hole to a depth of approximately 6 inches and the time required for the water to drop a designated amount is measured.

A septic drain field requires wastewater to enter and pass through the soil profile fast enough to prevent backups that many cause the surface to become saturated with undesirable effluent. In addition to physically moving the effluent away from the surface, the soil should also filter pathogens and nutrients as water flows between the soil subsurface and the groundwater table. Therefore, soils should have sufficient aeration to support adequate biological activity. Biological activity will destroy pathogens as the effluent moves through the profile towards the water table.

Exercise A Perc Test

Normally this test is repeated a minimum of three times until the time for the water to drop two successive tests is approximately equal. The longest time interval is taken as the stabilized rate of percolation and serves as the basis of design for the absorption field. Due to time and space constraints, we will conduct only one perc test per lab. Your TA will give you the percolation data for the other three lab groups.

Materials

- 5 gallon pail of water and water bottle
- stopwatch
- ruler or measuring tape
- hand-held penetrometer
- clinometer

Steps

1. Set a stopwatch at 0:00 and have a ruler or measuring tape ready for use.
2. Pour clean water into a hole, with as little splashing as possible, to a depth of 15 centimeters above the bottom of the test hole.
3. Observe and record in Table 1 the time, in minutes, required for the water to drop from the 15-centimeter depth to the 12.5-centimeter depth.
4. Determine compaction with the hand-held penetrometer near the perc hole. Record result in Table 1.
5. Determine texture of soil using the texture by feel method and record in Table 1.
6. Measure slope and record in Table 1.
7. Determine the percolation rate for this site with your data and the data from the other three labs (your TA will give you).

Exercise B Turfgrass Test Plots Infiltration

Materials

- infiltration rings
- rubber mallet
- stopwatch
- ruler or measuring tape
- 5 gallon pail of water
- hand-held penetrometer

Steps

1. Set stopwatch to 0:00 and have a ruler ready for use. Place double ring cutting blades on turf area to be tested. Record texture in Table 2.
2. Push down on handle grips while slightly turning instrument back and forth until rings are approximately five centimeters into the soil. Do not move instrument side to side or twist too much because grass roots will shear and you'll remove a plug.
3. Fill the inner ring first and allow it to spill over to the outer ring. Then fill outer ring till it slightly overflows.
4. Start the timer immediately when the water is at the top of the inner ring and measure the amount of water (centimeters) in the center ing by inserting ruler/measuring tape into water until it reaches the soil surface. Record.
5. Measure the amount of water in the center ring every minute for 10 minutes. Make sure you measure at the same location each time. Record
6. Determine compaction next to infiltration rings and record in Table 2.
7. Calculate the infiltration rate in centimeters for each minute
8. Calculate hourly infiltration rate by multiplying the rates above by 60.
9. To remove the instrument from the turf, use the handgrips to lift the cups straight out of turf. The handles may also require a slight turning while lifting the tool out of the ground. Extract the tool slowly in order not to disturb the turf surface.
10. Repeat steps 1-9 in the other plot and record data in Table 2.

Exercise C Golf Course Infiltration

Materials: Same as exercise B
Steps: You will repeat Exercise B at the Golf Course. Record your data in Table 3. Your TA will explain how to record this data on the Water Infiltration Sheet. .

Tables

Table 1 Perc Test Results

Soil texture:	Slope:	
Test Number	Minutes for 2.5 cm drop	Compaction
1-Monday		
2-Tuesday		
3-Wednesday		
Percolation rate:		

Table 2 Turf Plot Infiltration

	Texture: Compaction:			Texture: Compaction:		
Time	Water depth (cm)	Infiltration cm/min	rate cm/hr	Water depth (cm)	Infiltration cm/min	rate cm/hr
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Table 3 Golf Course Infiltration Measurements

	Site: Compaction:			Site: Compaction:		
Time	Depth (cm)	Infiltration rate cm/min	 cm/hr	Depth (cm)	Infiltration rate cm/min	 cm/hr

Assignment

1. Based on the data we collected over the four days, plot an infiltration curve and determine the saturated infiltration rate for the **Perc test** (exercise A), the **two turf plots at the research farm** (exercise B) and the **four turf plots as the golf course** (exercise C). Use all four days of data to determine the average rates over the four days. Display the curves that you produce in addition to the determined saturated infiltration rate.

2. Case Study: The Tompkins County Health Department wants you to evaluate our perc test site for the installation of septic and absorption field system. The soil series of the site is a Hudson-Collamer silt loam. Some things to keep in mind:

- slopes greater than 15 percent are unacceptable
- there must be at least four feet of usable soil (percolation rate faster than 60 min/inch) available above rock, unsuitable soil, or high seasonal ground water, for the installation of a conventional absorption field system
- Soils with very rapid percolation rates (faster than one minute per inch) are not suitable for subsurface absorption systems unless the site is modified with less permeable soil to reduce the infiltration rate throughout the area to be used
- The highest groundwater level has to be determined, including seasonal high groundwater level and type of water table – perched or apparent

Based on the data we collected over the four days, use the previously plotted infiltration curve and determined the saturated infiltration rate to evaluate the site. Comment on any additional information you need and why.

3. Given your understanding of the effects of soil texture and structure on infiltration rates (Exercise B), how would you evaluate the infiltration rates in Exercise C. What, if any, soil management recommendations would you make?

References

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