LABORATORY 5

SATURATED HYDRAULIC CONDUCTIVITY

I Objective

Gain familiarity with a common method used to determine saturated hydraulic conductivity.

II Introduction

Liquid water moves under saturated and unsaturated conditions. Diffusion of water vapor also occurs. Rate of water movement in soil is important to a host of agricultural, engineering and environmental concerns. This laboratory exercise introduces a common method used to determine ***saturated hydraulic conductivity***, that is, conductivity when pore space is saturated with water.

The saturated hydraulic conductivity of a soil depends on the pore size distribution. Since large pores conduct water much more easily than small pores, the saturated hydraulic conductivity of a sand is much greater than that of a clay. Soil structure, as well as texture, also affects saturated hydraulic conductivity. Comparatively large interaggregate pores increase saturated hydraulic conductivity as do any other ***macropores***, including earthworm burrows and root channels in undisturbed soil.

Saturated hydraulic conductivity can be calculated by first measuring all variables in ***Darcy's Law***, then substituting these values and rearranging for saturated conductivity.

$Q = K_{sat} A [(H_{inflow} - H_{outlow}) / z]$

where

Q is volumetric flow rate	(cm^3 / h)
A is cross sectional area	(cm^2)
H is hydraulic head	(cm)
z is flow length through soil	(cm)
K_{sat} is saturated hydraulic conductivity	(cm / h)

Darcy's Law gives the volume of water per unit time that passes through an imaginary plane of area A perpendicular to the direction of water flow.

Under saturated conditions the hydraulic head at any position is the sum of gravitational and pressure potentials, $H = h_g + h_p$. Hydraulic head is water potential expressed as energy per unit weight, thus, it has the dimension of length. Gravitational head at any position is measured with respect to a reference level and pressure head is expressed as depth below a free water surface at atmospheric pressure. For example, in Fig. 1, $H_{inflow} = h_{g\ inflow} + h_{p\ inflow} = Z + D$ and $H_{outflow} = h_{g\ outflow} + h_{p\ outflow} = 0 + 0$.

The ratio $(H_{inflow} - H_{outlow}) / z$ is the ***hydraulic gradient***, the decrease in hydraulic head with distance in the direction of water flow. This decrease in water potential is the cause of water flow.

III Procedure

You will measure the volume of water per time flowing through soil of known cross sectional area and height. The soil will be saturated and the surface under a small pressure head. Therefore, by rearranging the above expression for Darcy's Law and inserting these data, several estimates of K_{sat} can be obtained.

1. Measure and record the dimensions of a section of plastic pipe (Table 1). Also record mass.

2. Stretch several layers cheesecloth across one end of the pipe section and secure with rubber bands.

3. Add soil and fill to 5.0 ± 0.1 cm below the rim. Record the air-dry mass of soil (Table 2) and depth to which pipe was filled. Try to get uniform bulk density by adding soil in increments and gently tamping down each added increment.

4. Set the apparatus upright in a beaker filled with tap water and allow soil to saturate. The surrounding height of water should be below the top of soil.

5. Label three Mason jars # 1 – 3, weigh each and record.

6. Once the soil appears saturated (glistening surface), slowly add tap water to almost fill the pipe.

7. Transfer to welded wire mesh set on top of jar 1. Fill pipe to as close to the rim as possible with tap water and begin timing immediately. Keep headspace nearly filled at all times.

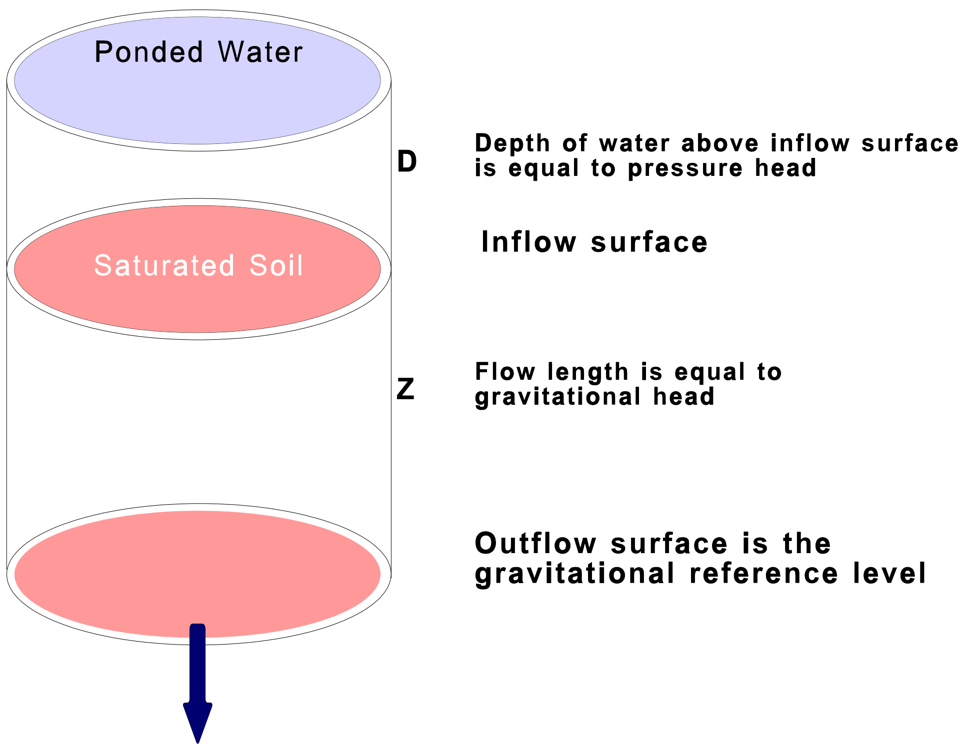
8. After collecting about 50 mL of percolate (about 1 cm depth in jar) or after collecting for about 10 min, whichever comes first, switch to waste jar and record elapsed time and mass of jar + percolate collected (Table 3).

9. Repeat two times.

10. Dump soil / water into waste bucket. Throw out cheesecloth and bands. Wash all other apparatus and dry.

11. Calculations.

    Three estimates of K_{sat} and average of these (Table 3).



IV Worksheet and Questions

A Saturated Hydraulic Conductivity

Table 1.

Length (cm)	Area (cm)	Mass (g)

Table 2.

Mass of Soil (g)	Depth of Soil (cm)	Air-dry Moisture %	Bulk Density (g / cm^3)

Calculations

Table 3.

Jar Mass	+ Percolate	Percolate (cm^3)	Hydraulic Gradient	Time (min)	K_{SAT} (cm /min)
Average					

Calculations

B Questions

1. The saturated hydraulic conductivity of soil A is 1.00 cm / hr and the saturated hydraulic conductivity of soil B is 0.01 cm / hr. Through which soil would a chemical contaminant more quickly move?

2. Fill in blanks in the below table.

Q **Flow Rate** **(cm^3 / hr)**	**A** **Area** **(cm^2)**	**K_{sat}** **Conductivity** **(cm / hr)**	**Z** **Flow Length** **(cm)**	**D** **Water Depth** **(cm)**
100	10		20	20
	100	1	100	0