SSC 107 - Laboratory Exercise 3

Determining Soil-Water Content Using the Neutron Moisture Meter

Introduction

The fundamental method of determining soil-water content is by drying the soil sample at 105 C until no further loss in mass is recorded. The major drawback of this method is that it is destructive(by removing a soil sample you disturb the site you are measuring). The oven drying method is also very time consuming.

One method of non-destructive soil-water measurement is the use of a neutron moisture meter. Neutrons are primary particles with the same mass as a hydrogen atom that carry no charge. When a radioactive source emitting high energy or "fast" neutrons is placed in the soil, the neutrons collide with the nuclei of surrounding atoms and are scattered randomly in all directions. Physical theory dictates that the maximum amount of energy transferred from one particle to another by collision, occurs when the two colliding particles have approximately the same mass. Thus the average energy loss of a fast neutron is much greater in collisions with atoms of a low atomic weight. In soils, hydrogen is the low atomic weight atom present in the largest quantities.

The neutron probe has a detector for slow neutrons ("fast" or high energy neutrons which have lost their energy by collision with hydrogen). Thus the number of slow neutrons is indicative of the hydrogen content of the soil. In most soils, hydrogen is present mainly as water. Thus the slow neutron count is a measure of the volumetric moisture content of the soil.

The objective of this exercise is to measure the soil-water content in a field site using the neutron moisture meter. Neutron probe access tubes will be installed and readings taken every 20 cm. Meter readings will be converted to soil-water contents using a standard curve.

Procedure

1. Install a thin walled aluminum access tube into the soil to a depth of 100 cm. The hole for the access tube is made by removing soil with an auger the same size as the outside diameter (4.13 cm) of the tube. Both ends of the tube should be covered with a #10 rubber stopper.

2. Check and clean the tube to make sure the neutron probe can slide easily. This is accomplished by lowering a dummy probe (a piece of metal the same size as the probe) down the access tube.

3. Turn the moisture meter to the "on" position. Check to see if the high voltage setting is correct (operating voltages are different for different meters and will be given to the students). Turn the mode switch to the "calibrate" (or STD) position. Set the timer switch to 1.0 (1 min). Take a standard reading. A standard reading is one where the neutron source is still inside the shield. The shield is a source of constant high-density hydrogen atoms. The reading (counts) at this point gives an indication of the total number of neutrons being emitted.

4. Turn the mode switch to the read position. Place the probe over the access tube. Lower the probe to the desired depths (every 20 cm) and take a 1 minute count at each depth.

5. Using the standard curve for the meter convert the neutron readings to soil-water content.

Note: The neutron moisture meter was built for rugged field use, but it still contains sensitive electronic components. Careful handlingof the meter is required at all times.

Appendix: Standard curve

Neutron access tubes are lowered into holes from which volumetric soil samples were extracted. Bulk density, ρ_b, and gravimetric soil-water content, w, are determined from the oven-dried volumetric soil samples. Volumetric soil-water content, θ, calculated from $\theta = \rho_b * w$, is compared with the neutron counts when the access tubes were installed. Since soils are heterogeneous in composition and bulk density, and different access tube material (usually aluminum and PVC) affects neutron absorption differently, a standard curve is only good for the sampled soil area, and type/thickness of access tube.