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# Measurement Techniques and Soil Water Terms

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There are various means to measure both soil water content (both volumetric and gravimetric) and soil water potential. This assignment will also explain the meaning of several soil terms that depend on the measuring techniques that follow.

Augering is a gravimetric technique where a soil sample is obtained by drilling a core in the soil. Typically, the volume of the soil is not needed, but the mass is important. The sample is weighed before being dried in an oven for a long period of time, but recently microwaves have found their way into the process, thus speeding up the time the soil needs to dry. The sample is then weighed after becoming dry. The advantages to this technique are that it is one of the most accurate means of measuring soil water content; the results obtained using this technique are the standards to which other techniques are compared. It is also relatively cheap since there is no complicated electronics involved. The main disadvantage to augering is that it is a destructive technique and can only be performed once on a given soil sample. Also, while the sample is being transported to the lab, some soil water may be lost in the process, thus changing the results. Additionally, it is labor and time intensive and is a poor method to use in soils with a high organic matter content.

Neutron scattering is a method where a probe is inserted into the soil and that probe emits fast moving neutrons, which are slowed by the presence of H nuclei in the soil. The number of slowed down neutrons is proportional to the number of H nuclei in the soil, and since hydrogen is present in water, more H nuclei signify more water. The probe measures the density of slowed neutrons spread spherically around the release point of the probe. The probe itself needs to be calibrated to take into account other sources of H nuclei in the soil along with other atoms that may slow the neutrons by the same amount a H nucleus would. The advantages to this method are that it can be done more than once on the same soil sample and that the equipment is

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relatively cheap. The disadvantages include the fact that this technique cannot be performed near the surface of the soil because the neutrons would escape into the air where they cannot be measured, the radiation hazard associated with producing neutrons, and the licensing requirements for a neutron-emitting device.

Electrical resistance can be used to measure soil water content as well. Electrodes are placed into a porous matrix and connected to a device that measures electrical resistance in the matrix. The matric potential of water is determined through the measured electrical resistance, and at equilibrium the sensor matric potential should be equal to soil water matric potential. Soil water content can be measured indirectly from the relationship between the sensor matric potential and the soil water matric potential. The advantages to this technique include its low cost and the fact that it is easy to use. Its main disadvantage is its lack of sensitivity in wet conditions.

Time domain reflectometry measures the dielectric constant, which determines how fast an electromagnetic wave can travel in a wire embedded in the ground. Some of the advantages are that soil composition and texture do not interfere with the method, so it is a good way to measure liquid soil water. If combined with neutron scattering technique it can measure volumetric liquid and frozen water content very accurately with little calibration required and no radiation hazards. The measurements are easy to obtain and can be automated. Some disadvantages of this method are that its expensive, does not work well in saline solutions and clays since they have highly charged surfaces. Its accuracy is within 1kPa.

Water content reflectometry measures soil volumetric water content based on changes in soil dielectric permittivity. An oscillator circuit is connected to parallel rods which are placed into a specific volume of soil and as soil water content changes, the dielectric property changes,

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and that alters the oscillation frequency of the circuit. This method is sensitive to soil solution conductivity.

To measure soil water potential, specifically matric potential, a tensiometer may be used. It is a glass or plastic tube that is filled with water (See Diagram 1). At one end, the tube is sealed and has a vacuum gauge (or a rubber cap which can be punctured by a needle to measure the pressure in the tube) while at the other end, the tube is covered with a porous ceramic tip. It is placed into the soil in the vadose zone and as water leaves the soil, either through evaporation or by plant uptake, a vacuum is created since water in the tube flows out the porous ceramic tip toward the drier soil. This method is inexpensive, can be automated, and is accurate to within .2 to 1kPa, all of which are advantages. The disadvantages are that it is accurate only within a limited range and that it needs periodic servicing.

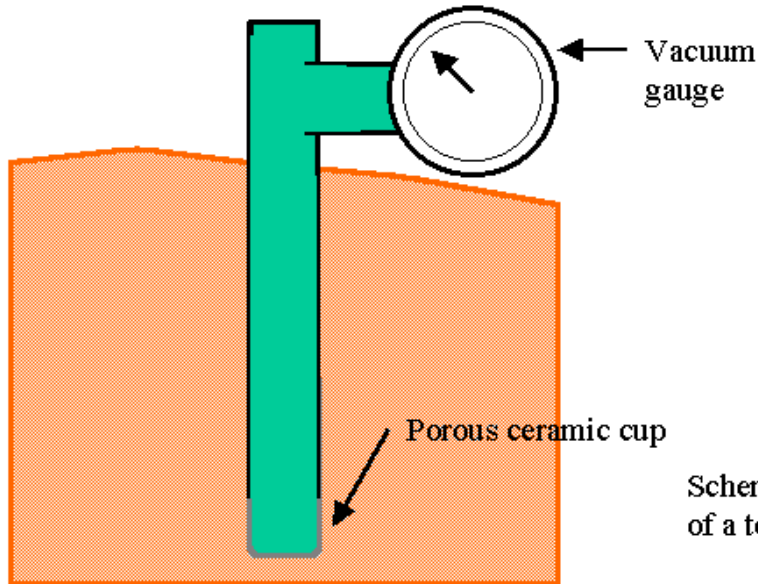
A piezometer is a hollow tube in which the bottom end is perforated to let soil water in. It is placed vertically in the soil below the water table and extends up to the atmosphere. The soil water rises to a height equal to that of the free water table and is then measured, giving hydrostatic pressure potential.

A psychrometer consists of two thermometers. One thermometer is kept wet while the other is kept dry. It measures the relative humidity of water vapor by taking the temperature difference between the two bulbs of the thermometers. This can give the soil water potential because at equilibrium, the soil water potential is the same as the potential of the soil air water vapor. The soil water potential of the vapor in the soil is the sum of the osmotic and matric potentials.

Terms that depend on the above measurement techniques are soil water storage, field capacity, wilting point, hygroscopic water, and available water (See Figure 1). Mathematically,

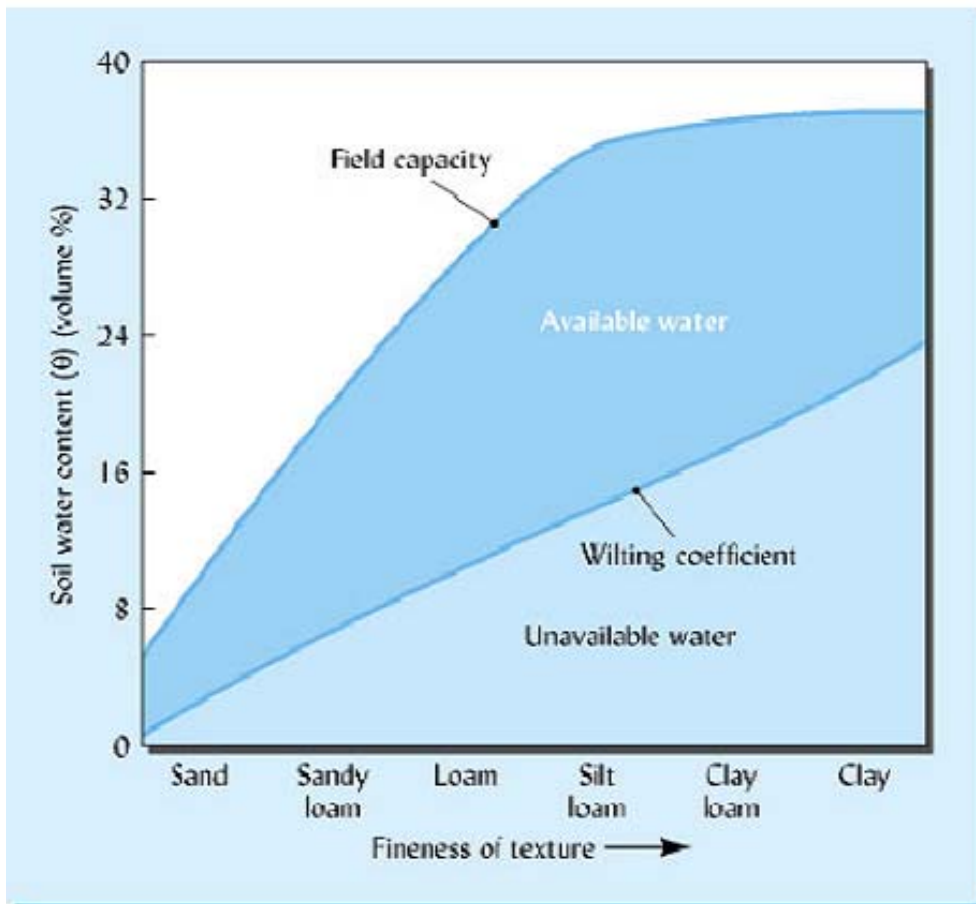
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soil water storage is the summation of the product of the soil depth increment and volume water content. This gives soil water depth and allows us to understand below ground water amounts as though they were expressed as a lake or other above ground water supplies. This means that soil water storage would be the same as if the soil water was extracted from the soil and put into a bucket to be measured. Field capacity is the amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2–3 days after a rain or irrigation in pervious soils of uniform structure and texture. At field capacity, soil is holding the maximum amount of water useful for plants. Typically, there is no water in the macropores because air has taken its place after it has drained. The micropores still hold the water available for plant use, but the movement is very slow because capillary forces, rather than gravitational force, control it. Wilting point is the point at which the amount of water that plant roots take up is not greater than the amount of water lost through the leaves. This typically occurs at  $-1500$  kPa. Pore space is dominated by air but some water remains adhered to the soil particles in a layer of water up to ten molecules thick. Hygroscopic coefficient is similar to wilting point in that pore space is dominated mostly by air and the remaining water resides in a layer of water molecules only 4-5 molecules thick around the soil particles. The only way the water can move in this dry soil is through the vapor phase. The water potential of the soil is  $-3100$  kPa. Available water is the amount of water at a water potential less than field capacity, but more than wilting point and is greatest in silt loams. Available water is affected by the soil texture (whether its silt, sand or clay), the quantity of organic matter (more organic matter improves water availability by improving soil structure and infiltration capacity), and compaction (the more compacted the soil, the less it holds).



**Diagram 1:** A tensiometer

Schematic diagram  
of a tensiometer



**Figure 5.25:** A graph showing water availability in different soil textures

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Figure 5.25 General relationship between soil water characteristics and soil texture. Note that the wilting coefficient increases as the texture becomes finer. The field capacity increases until we reach the silt loams, then levels off. Remember these are representative curves; individual soils would probably have values different from those shown.

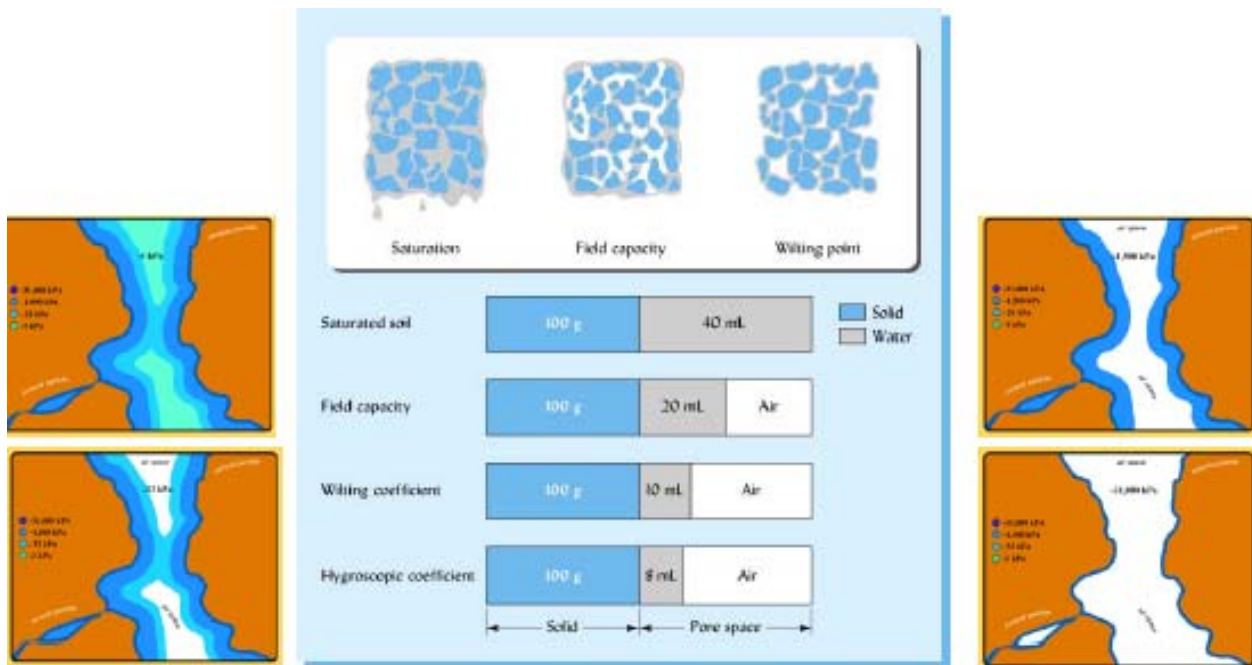


Figure 5.23 Volumes of water and air associated with a 100 g slice of soil solids in a well-granulated silt loam at different moisture levels. The top bar shows the situation when a representative soil is completely saturated with water. This situation will usually occur for short periods of time during a rain or when the soil is being irrigated. Water will soon drain out of the larger pores (macropores). The soil is then said to be at the field capacity. Plants will remove water from the soil quite rapidly until they begin to wilt. When permanent wilting of the plants occurs, the soil water content is said to be at the wilting coefficient. There is still considerable water in the soil, but it is held too tightly to permit its absorption by plant roots. A further reduction in water content to the hygroscopic coefficient is illustrated in the bottom bar. At this point the water is held very tightly, mostly by the soil colloids. (Top drawings modified from *Irrigation on Western Farms*, published by the U.S. Departments of Agriculture and Interior)

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### **References**

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