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Soil Moisture Sensor

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ARTICLE ID: 051

What does soil moisture even mean?

Soil moisture is more than just knowing the amount of water in soil. There are basic principles you need to know before deciding how to measure it. Following questions may help you focus on what you're actually trying to find out.

- Are you interested in the ground water stored in the soil?
- Do you care more about the water available for primary productivity to maximize production or understand maximum production in your field?
- Are you studying water and solute movement in soils?
- Do you aim to optimize water use of crops?
- Are you modelling soil hydrology?

Depending on which of these questions you are interested in, soil moisture might mean something very different.

Know which variable you should measure

Most people look at soil moisture only in terms of one variable: soil water content. But two types of variables are required to describe the state of water in the soil: water content, which is the amount of water and water potential, which is the energy state of the water. Soil water content is an extensive variable. It changes with size and situation. It's defined as the amount of water per total unit volume or mass. Basically, it's how much water is there. Water potential is an "intensive" variable that describes the intensity or quality of matter or energy. It is often compared to temperature. Just as temperature indicates the comfort level of a human, water potential can indicate the comfort level of a plant. Water potential is the potential energy per mole (unit mass, volume, weight) of water with reference to pure water at zero potential. You can look at water potential as the work required to remove a small quantity of water from the soil and depositing it in a pool of pure, free water.

Technology

Technologies commonly used to indirectly measure volumetric water content (soil moisture) include:

Frequency Domain Reflectometry (FDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the operating frequency of an oscillating circuit.

Time Domain Transmission (TDT) and Time Domain Reflectometry (TDR): The dielectric constant of a certain volume element around the sensor is obtained by measuring the speed of propagation along a buried transmission line.

Neutron moisture gauges: The moderator properties of water for neutrons are utilized to estimate soil moisture content between a source and detector probe.

Soil resistivity: Measuring how strongly the soil resists the flow of electricity between two electrodes can be used to determine the soil moisture content.

Galvanic cell: The amount of water present can be determined based on the voltage the soil produces because water acts as an electrolyte and produces electricity. The technology behind this concept is the galvanic cell.

Applications in Agriculture

Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

Landscape irrigation

In urban and suburban areas, landscapes and residential lawns are using soil moisture sensors to interface with an irrigation controller. Connecting a soil moisture sensor to a simple irrigation clock will convert it into a "smart" irrigation controller that prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event. Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground.

Research

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

Simple sensors for gardeners

Relatively cheap and simple devices that do not require a power source are available for checking whether plants have sufficient moisture to thrive. After inserting a probe into the soil for approximately 60 seconds, a meter indicates if the soil is too dry, moist or wet for plants.

How to measure volumetric water content

Most volumetric water content measurements are made using some kind of sensor. METER water content sensors use capacitance technology. To make this measurement, these sensors take advantage of the "polarity" of water.

How does it work?

For example, the components of a known volume of soil are shown in Figure 1. All of the components total 100%. Since volumetric water content (VWC) equals the volume of water divided by the total soil volume, in this case, VWC will be 35%. VWC is sometimes reported as cm^3/cm^3 or inches per foot.

Gravimetric Water Content	VWC Sensors	Remote Sensing (SMOS)
First principles/direct method	Convenient for time series	Can do time series at limited scale
Time consuming	Enables profile sensing over time	Extremely powerful for spatial sampling
Destructive	Less intrusive	
Only 1 snapshot in time		