

2. Sensor Calibration

Capacitance sensors measure dielectric permittivity of media, which is then converted to soil volumetric water contents based on calibration equations. For most mineral soils, the relationship between dielectric permittivity and volumetric water content is similar and Topp equation is used. For soilless substrates however, this relationship is not constant for various substrates and it is generally advised to determine the relationship empirically by doing a custom calibration for the particular substrate – sensor combination.

It is worth mentioning here that someone can also completely bypass calibration and use the raw output of capacitance sensors as long as understanding is developed for ranges of raw sensor readings and corresponding soil moisture status. This method, however, is very subjective and moisture status cannot be expressed in measurement units (% VWC). It is therefore strongly advised to do a custom calibration for the sensor-substrate combination whenever possible. With custom calibration, VWC can be accurately predicted in soils, substrates and other mixes. Below, some methods that can be utilized to generate calibration equations are given.

Dry Down Methods

In dry down methods, sensors are placed in containers of known volume filled with wet substrate to take continuous measurements. The mass of the container is periodically measured as the substrate dries down. Sensor readings then can be related to corresponding volumetric water contents obtained for the sample to generate a relationship. This method has the advantage of mimicking environmental conditions and minimizing disturbances. However, it is unlikely to give good results as sensor readings are affected by the position of the sensor in relation to the drying front. In addition, the method can take long time, depending on how fast the soil/substrate dries out.

Wetting Methods

Simple calibration procedures that can be used to generate curves quickly and without the need for expensive equipments are available. Below, the steps for the “Homogenized Substrate Method” recommended by Decagon Devices, Inc. are outlined. This method starts with a dry soil/substrate and water is applied to progressively wet the soil/substrate to the desired soil moisture level.

1. Prepare an empty, open-end container of known volume or volume markings. It is recommended to have containers with dimensions bigger than the sensor to be calibrated (or with bigger volume than the volume of influence of the sensor).
2. Weigh the empty container (W_1).
3. Pack the dry soil/substrate into the container to the desired bulk density. Note the volume.
4. Weigh the container and dry sample (W_2). $W_2 - W_1$ gives the dry soil mass. The ratio of dry soil mass to the volume gives the bulk density.
5. Carefully insert the sensor and take readings.

6. Spread the sample on a large container. Add arbitrary amount of water, mix thoroughly and pack the moist substrate in the original container to its initial volume. Weigh the container with moist substrate (W_3). $W_3 - W_2$ gives the mass of the added water. The ratio of mass of water to the volume gives volumetric water content.

7. Insert sensor into the packed substrate and take multiple readings.

8. Repeat 6 and 7 continuously to progressively increase the moisture content of the sample until the desired VWC range is obtained.

9. The relationship between the sensor reading and volumetric water content can then be derived from the data collected.

One limitation of this method is that it is hard to control the bulk density of the sample as water is added. In addition, this method is useful only to disturbed samples.

The methods mentioned above can be used to make custom calibrations and quickly generate calibration equations. However, precision substrate calibration procedures that can be utilized for research purposes are also available.