



EFFECTS OF SAMPLE DISTURBANCE ON SOIL WATER POTENTIAL MEASUREMENTS WITH THE WP4C

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Sample disturbance is often a concern when water potential is measured. Most researchers try to minimize sample disturbance and thereby ensure a more representative measurement. Sample disturbance, however, is inevitable. The purpose of this note is to assess the magnitude of sample disturbance effects and relate them to the range of water potential of the soil sample.

A soil is often modeled as a bundle of capillary tubes with a wide range of pore sizes. As shown in Table 1, a unique relationship exists between the water potential associated with a given pore size and the diameter of the pores. This relationship comes from the Young-Laplace equation, which relates the water potential of water beneath an air-water interface to the curvature of that interface.

	MPa	pF	Pore Diameter (μm)
	-0.001	1.01	290.08
	-0.01	2.01	29.01
Field Capacity	-0.033	2.53	8.79
	-0.1	3.01	2.90
	-1.0	4.01	0.29
Perm. Wilting Pt.	-1.5	4.18	0.19
	-10	5.01	0.03
Air Dry	-100	6.01	
Oven Dry	-1000	7.01	

Table 1. Water potential units: MPa comparison to pore diameter and pF

The water in the largest pores is the most loosely held and is the first to be lost as the soil dries. As the soil becomes drier, the residual water is held in smaller pores. Eventually the capillary analogy breaks down, and the water is held mainly as adsorbed films on particle surfaces. The relationship between water potential and water content for a soil is called a “[moisture release curve](#)”, or “moisture characteristic”.

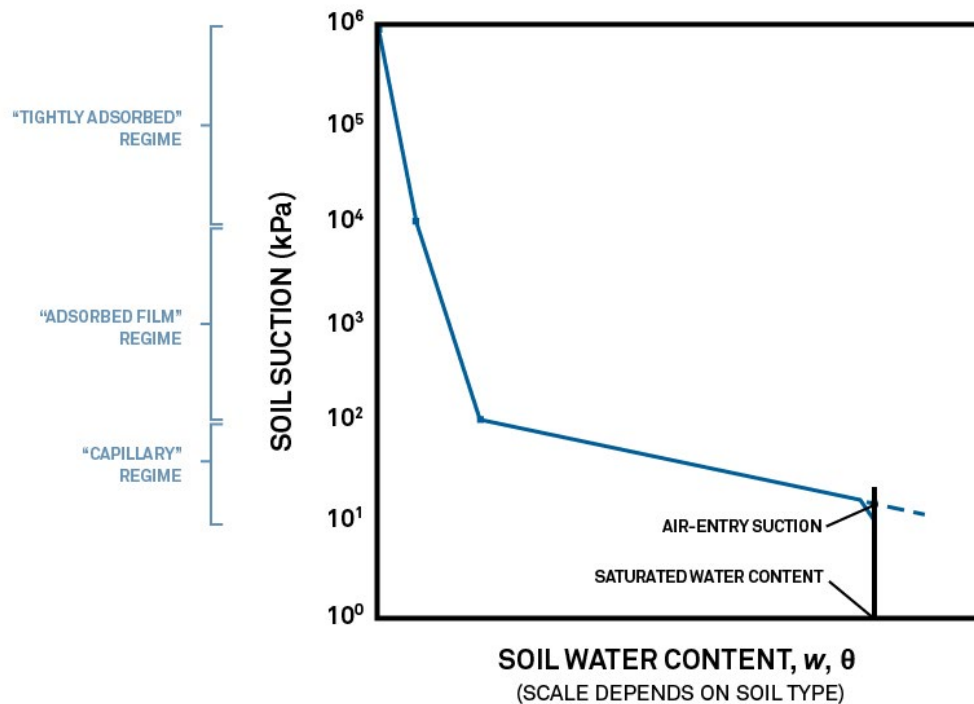


Figure 1. Idealized soil moisture characteristic from Lu and Likos (2004) showing the three soil moisture retention regimes

The soil moisture characteristic can be broken into three approximate ranges based on the forces that hold water in the soil:

Tightly adsorbed: oven dry to $-10,000$ kPa

Adsorbed films: $-10,000$ to -100 kPa

Capillary water: -100 to 0 kPa

Soil disturbance and changes in bulk density mainly alter the sizes of the largest pores. Disturbance can therefore strongly affect the [water content-water potential relationship](#) of samples in the capillary range of potentials but has negligible effect on the water potential of samples in the tightly-adsorbed and adsorbed film ranges. This is shown in Figure 2, from Box and Taylor (1962). They investigated the effects of bulk density on the moisture characteristic. Figure 2 shows that the change in

density dramatically affects the [matric potential](#) when the soil is wetter than about -40 kPa but has little effect in drier soil. Campbell and Gardner (1968) obtained similar results.

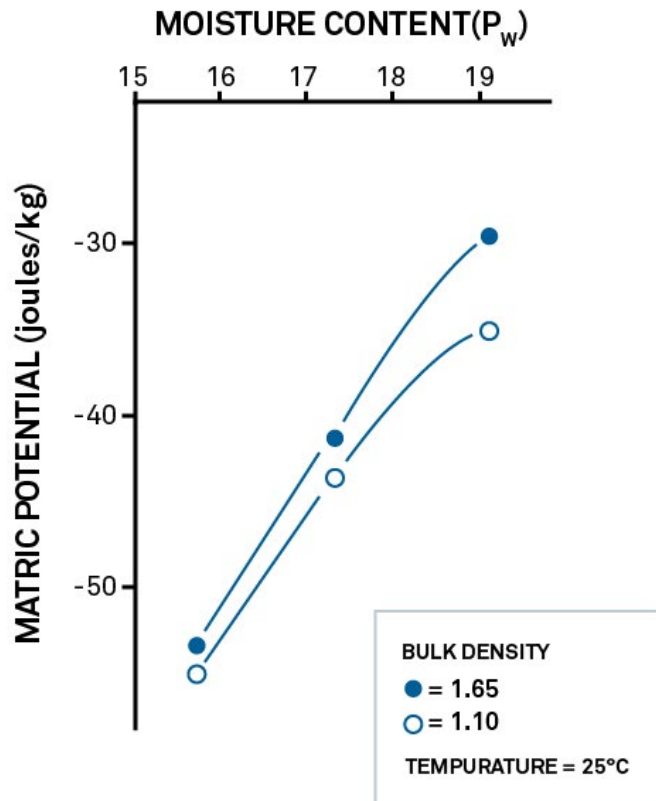


Figure 2. Box and Taylor (1962) graph showing changes in matric potential due to differences in bulk density. Note that the units of J/kg are equivalent to units of kPa.

The WP4C is accurate to ± 50 kPa in the wet range when used in precise mode, meaning that a measurement of -50 kPa has an accuracy of $\pm 100\%$. This measurement uncertainty is far larger than uncertainty due to density differences, so the effects of sample disturbance are likely negligible in this scenario.

Expert users of the WP4C can use continuous mode and extremely careful experimental methods to increase accuracy to ± 25 kPa and essentially [extend the functional measurement range](#) of the WP4C further into the capillary water range. If this type of careful research is being done, errors from sample disturbance could become non-negligible, and it is recommended to use minimally-disturbed samples in the WP4C.

[Download the “Researcher’s complete guide to water potential”](#)

REFERENCES

Box, James E., and S. A. Taylor. "Influence of soil bulk density on matric potential." *Soil Science Society of America Journal* 26, no. 2 (1962): 119-122. [Article link](#).

Campbell, Glen S., and Walter H. Gardner. "Psychrometric measurement of soil water potential: temperature and bulk density effects." *Soil Science Society of America Journal* 35, no. 1 (1971): 8-12. [Article link](#).

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