The Equi-pF: A new device for determining soil moisture release

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Introduction

The moisture release curve is a fundamental descriptor of soil water movement and storage. While tension table apparatii for defining drainage curves in the near-saturated region (0 to -100 cm water) have been available for many decades (Klute, 1986), there has been little advance in automating the process, particularly when measurements of wetting, drying and capillary conductivity are combined. We describe a new instrument, the Equi-pF, that uses a precision water flow measurement coupled with an accurately controlled variable hydraulic head to exactly define the relationship between matric potential and gravimetric water content from 0 to -100 cm H2O. The new instrument automates the process without any disturbance to the soil core and has fully programmable suction steps and equilibration times.

Objectives

- Describe the new automated Equi-pF moisture release curve approach

- Compare moisture release curves generated with the Equi-pF with:

  - published lab media results for four different sand size fractions

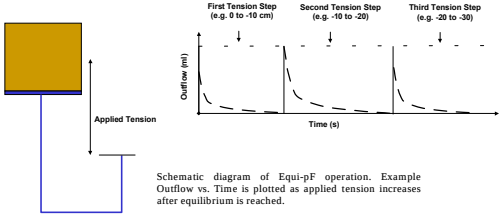
  -Eijkelkamp sand table results for new samples extracted from Watershed 10 experimental hillslope at the HJ Andrews

The Device

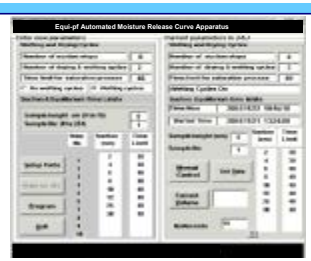
The Equi-pF approach

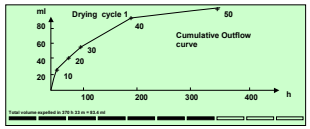
The Equi-pF apparatus is a fully automated traditional hanging water column tension table. It is designed to perform the following steps automatically:

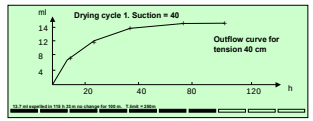
1: Saturate soil sample
2: Apply a series of pre-determined tensions
3: Measure outflow or inflow while waiting for equilibrium conditions
4: Analyze inflow and outflow data to plot the moisture release curve



Schematic diagram of Equi-pF operation. Example Outflow vs. Time is plotted as applied tension increases after equilibrium is reached.



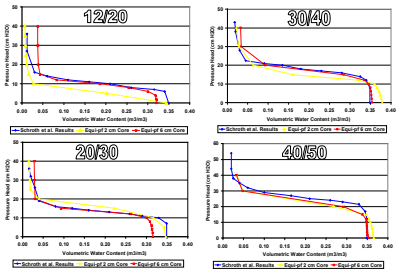




Screen shots of cumulative and single tension step outflow curves.

Comparison with published Accusand curves

Equi-pF was tested against 4 grades of Accusand. This laboratory sand has been well characterized by Schroth et al. (1996). Moisture release curves were determined for these size fractions using a three phase retention cell as described by Lenhard and Parker (1988) . We compare data reported in Schroth et al. with Equi-pF analyses for 12/20, 20/30, 30/40, and 40/50 sands (see table). We compare Equi-pF results for 2 cm and 6 cm depth sample cores.



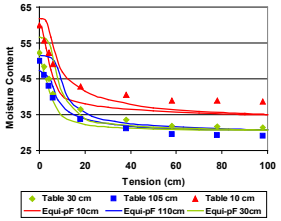
Equi-pF measured drying water retention curves for 2 cm (yellow) and 6 cm (red) cores, compared with published values (blue) from Schroth et al. (1996).

Accusand Grade	Permeability	Hydraulic conductivity	van Genuchten Parameters		Saturated Water Content	Residual Water Content
			n	alpha		
	m^2	cm/hr		1/cm	m^3/m^3	m^3/m^3
40/50	7.38E-11	259.8	12.2	0.045	0.348	0.020
30/40	1.52E-10	536.4	13.1	0.068	0.348	0.018
20/30	2.56E-10	901.2	10.6	0.100	0.348	0.016
12/20	5.15E-10	1811.4	7.4	0.151	0.348	0.012

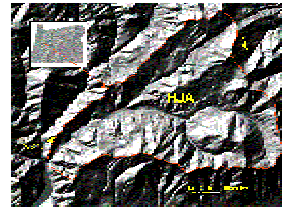
Physical parameters of Accusand samples (Schroth et al. 1996)

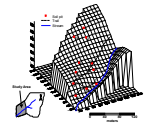
Comparison with traditional tension table using field soils

We compare cores taken from Watershed 10 at the HJ Andrews Experimental Forest at 10, 30 and 110 cm depth.

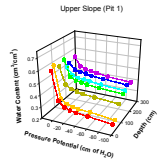


Equi-pF and Eijkelkamp sand table moisture release curves for field core samples taken from depths of 10, 30 and and 110 cm.





Sample Locations in Watershed 10, HJ Andrews



Summary of historical data from 452 soil cores from 11 pits, collected and described from the HJ Andrews site by Ranken (1974)

Results and Conclusions

Accusand Core Depth Effects:
The Equi-pF matched the published moisture release data for the Accusands. The 2 cm (12-20) cores did not produce a clear inflection point near the capillary fringe, whereas the 6 cm (12-20) cores did. Both 2 and 6 cm cores with finer (30-40 & 40-50) grains produced clear inflection points near capillary fringe.

Field Core Tests:
Equi-pF moisture release curves are within the range of values for cores extracted from the HJ Andrews Experimental forest and measured on the Eijkelkamp tension table.

References

Klute, A., (ed.) (1986). Methods of Soil Analysis, Vol. 1, pp. 1-1189. Soil Science Society of America, Madison WI.

Ranken, D.W. (1974). Hydrologic properties of soil and subsoil on a steep, forested slope. M.S. Thesis, Oregon State University, Corvallis, 114 pp.

Schroth, M.H., S.J. Ahearn, J.S. Selker and J.D. Istok (1996). Characterization of Miller-similar silica sands for laboratory hydrologic studies. Soil Science Society of America 60: 1331-1339.

Lenhard RJ, Parker JC. (1988). Experimental validation of the theory of extending two-phase saturation-pressure relations to three-fluid phase systems for monotonic drainage path. Water Resources Research 24(3): 373-80 .