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THE USE OF THE PRESSURE MEMBRANE APPARATUS TO DETERMINE SOIL MOISTURE CONTENTS AT pF 3.0 TO pF 4.2 INCLUSIVE

by

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Instructions for the determination of soil moisture with the pressure membrane apparatus were originally composed in 1956 from data of the following laboratories:

Agricultural Experiment Station - Groningen (at present Institute for Soil Fertility;
Department of Soil and Fertilizers of the State Agricultural University - Wageningen;
Laboratory for Soil and Crop Testing - Oosterbeek,
Institute for Land and Water Management Research - Wageningen.

After several years of experience it seemed worthwhile to revise and extend certain paragraphs of the directions for use.

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Pressure membrane apparatus and auxiliaries[x)]

pressure membrane apparatus;
cellophane membrane (Plain Transparent);
hydrophilic nylon gauzes;
rubber O-ring;
plastic rings (diameter approximately 3 cm., height 0.5 to 1.0 cm.);
steel cylinder with compressed air or nitrogen;
1- or 2-stage reducing valve;
pressure-gauge, 0 to 20 kg/cm^2, subdivision 0.2 kg/cm^2;
2 needle- or ball valves;
iron conduite pipe;
high pressure rubber hose (double canvas inlay);
hose cap nuts;
plastic tube;
burette (50 ml.) or measuring glass (100 ml.);
moisture boxes;
balance, accuracy 0.01 gram;
laboratory oven;
beakers (150 ml.) with watch glasses (diameter approximately 7 cm.);
spatula and small spoon.

x) see photograph in flap back cover.
The pressure membrane apparatuses shown on the photograph are constructed by the "Stichting Centrale Werkplaats" - Dr.S.L.Mansholtlaan 12 - Wageningen.
The price is about 475 Dutch guilders (approximately £ 47), 2 cellophane membranes, 2 nylon gauzes, rubber O-ring and 15 plastic rings included.

Soil samples

With the determination of pF-curves mainly two pressures in addition to the suction range pF 0 to pF 2.7[x] are applied, i.e. 2.6 atmospheres (pF 3.4) and 15 atmospheres (pF 4.2 - "wilting point").

Undisturbed soil samples must be used when the structure of the soil is of influence on the water retention.

For clay soils this applies for the pF 3.4 determination, whereas for the determination of pF 4.2 disturbed samples can be used.

[The pF-value at which it will become important to work with undisturbed samples will probably be in the range pF 3.5 to pF 4.0]

With sandy soils disturbed samples can be used for the determination of both pF 3.4 and pF 4.2.

In general it is recommended to use soils taken under natural moisture conditions, by preference at approximately field capacity.

Artificial drying, grinding and sieving must be avoided.

Stones, concretions, roots etc. have to be removed.

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x) see: The use of the sandbox-apparatus to determine pF-curves in the range pF 0.4 to 2.7. Note No. 81 - june 1961 of the Institute for Land and Water Management Research - Wageningen.

PROCEDURE

I. Preparing the samples

Moisten the loose samples, taken in the field, before arranging then in the pressure membrane apparatus by carrying out the following instructions:

Transfer some 100 grams of the sample into a beaker of 150 ml. without disturbing the natural crumbling.
Add water carefully until the soil is nearly saturated; avoid stirring, especially with the determination of the pF 3.4-moisture content (the soil may not become puddled); clods of clay should be submerged in water for the greater part.
Cover the beaker with a watch glass to prevent evaporation.
Samples with an initial moisture content of about field capacity are sufficiently saturated in 1 (sand) to 2 (clay) days; for samples being naturally dry, the following standing periods are adhered to:

coarse sands	: 1 - 2 days
sandy and loamy sandy soils	: 2 - 3 "
loamy soils	: 2 - 4 "
silty and clay loam soils	: 3 - 4 "
heavy clay and peaty soils	: 4 - 5 "

II Preparing the pressure membrane apparatus

. Cut a piece of hydrophilic nylon gauze (mesh about 500 to 600 micron) of such a size that it will cover the area inside the groove of the bottom plate.

. Cut a piece of hydrophilic nylon gauze (mesh about 200 to 400 micron) of a size equal to the coarser gauze.
Both gauzes can be used many times.
After use the nylon gauzes should be cleaned in pure water or after use with iron-rich soils in a diluted acetic acid solution.
If the gauzes become greasy they can be cleaned with alcohol or a detergent.

. Cut two pieces of cellophane membrane (plain transparent cellophane, weight approximately 60 grams per square meter, designation: P.T. 600) of such a size that they project 1 to 2 cm. outside the bottom plate of the apparatus.
Although often the membranes can be used repeatedly, it is advisable to take new membranes for each test.

. Immerse the membranes in pure water for at least 1,5 hours (otherwise later on they will ruck up and crack during use), but preferably no longer than 20 hours (otherwise the cellophane becomes too soft and is subsequently easily damaged).
The moist membranes must have a matty aspect.

. Clean the sealing surfaces of bottom plate and cover of the apparatus very carefully (a grain of sand may puncture the membrane)

Place successively the already wetted coarse and fine nylon gauze on the bottom plate.

Spread the two layers of cellophane evenly over the finer nylon gauze, noting that the visible "grain" of both membranes should coïncide, such to ensure shrinkage into the same direction in case of drying out.

Remove entrapped air by passing the hand radially over the membrane.

Proceed quickly now, the membranes dry fairly soon and shrink in one direction.

III Filling the pressure membrane apparatus

Arrange the numbered plastic rings on the wet membrane. Fill the rings with the moistened soil from the beakers (with heavy clays cut a piece of a clod the size of the ring contents), using a small spoon, from which the soil is wiped off into the ring with a spatula..

The spatula is also used to "vibrate" the soil in the ring somewhat to prevent air entrapment and to press the soil a little to achieve good contact with the membrane.

Good adherence to the membrane may also be promoted by shifting the filled-up ring a little.

A small container with in water drenched cotton-wool is placed in the pressure chamber to realize a high relative humidity. For the determination of the 15 atmosphere percentage the cotton-wool may be drenched in a saturated solution of ammonium oxalate or barium nitrate (relative humidity approximately 98,85% - pF 4.2)

In order to check the results, it is recommended to fill one ring with a homogeneous soil of known moisture content at pF 3.4 and pF 4.2.

A porous material other than soil may also be used for this purpose.

If the moisture content of the standard sample differs from the proper value by more than approximately 5%, the determination should be repeated.

It is recommended to operate with duplicate samples. As 15 rings fit on the membrane, 7 soils and the standard sample can be determined together.

IV Putting the apparatus into operation

Place the rubber O-ring on the membrane, taking care not to cause soil particles to become wedged in between.

Carefully place the lid on the bottom plate and close the apparatus by tightening the square threaded spindle.

Open the valve of the gas-cylinder only after it has been established that the adjusting-screw of the reducing valve has been slackened off completely.

See to it, that the valve between conduite pipe and apparatus is opened and the outlet-valve is closed.

In order to obtain the required pressure the adjusting-screw of the reducing valve is tightened slowly until the pressure on the gauge reads 2.68 kg/cm^2 (2.6 atmospheres - pF 3.4) or 15.50 kg/cm^2 (15 atmospheres - pF 4.2)

If the pressure is rising somewhat too high, open the outlet-valve carefully to release gas until proper pressure and slack back the adjusting-screw of the reducing valve a little.

As cylinder-gas either air or nitrogen may be used. For soils with a high organic matter content however, nitrogen is recommended to prevent oxidation of same.

Leakages can be detected by observing the pressure gauge, the valve between conduite pipe and apparatus having been closed temporarily.

If the leakage is due to a puncture in the membrane a continuous and rapid stream of air bubbles will escape from the plastic outlet tube when the end of it is immersed in water.

Leakage along the circumference of the bottom plate or through the hose cap nuts can be traced by the application of a solution of soap or detergent.

A continuous air current through the apparatus due to leakage either of the membrane or of the apparatus itself will cause the samples to dry. In that case the whole procedure has to be carried out again with new samples.

Only when a leakage is detected within the first hours of the

experiment and the samples are found to be still wet, it is justified to use the same samples again.

By measuring each day the waterlevel in the burette or measuring glass it can be determined whether the outflow has ceased indicating that equilibrium has been reached.

The time needed to reach equilibrium depends on soil type and will take for:

light sandy soils	3 - 5 days
sandy and loamy sandy soils	4 - 7 "
loamy, silty and clay soils	6 - 8 "
heavy clay and peat soils	8 - 11 "

V Opening the apparatus

. Close the valve of the gas-cylinder;

. Open the outlet-valve at the end of the conduite pipe a little to ensure a slow decrease in pressure. Close the outlet-valve when the pressure-gauge indicates approximately 1 atmosphere;

. Loosen the screw spindle slowly until the gas escapes from the pressure chamber, then unscrew completely and remove the lid from the bottom plate and the O-ring from the membrane;

. Finally slacken off completely the adjusting-screw of the reducing valve to enable a new test to be commenced.

VI Determination and calculation of soil moisture percentages

Remove the rings filled with soil quickly from the membrane and press the soil with a spatula into numbered moisture boxes and put the numbered lids on.

It is preferable to use light-weight moisture boxes (e.g. made of alluminium) with close fitting lids; the weight of the boxes with the lids must be known.

Weigh the filled moisture boxes and dry them inside a laboratory oven at 105°C, having removed the lids first.

Constant weight is obtained after 12 to 18 hours of drying, the boxes complete with lids are weighed directly on a precision balance to an accuracy of 0,01 gram.

Calculation: Subtract the "dry" weight of the filled boxes from the weight before drying in order to obtain the moisture weight. By multiplying this value with 100 and dividing by the ovendry weight of the soil (= "dry" weight of filled boxes minus empty weight of the boxes) the moisture percentage on a dry weight basis is known.

Convert the average percentage of weight of duplicate samples into volume percentage with the aid of the volume weight of the soil, as known from the average dry weight of two volumetric samples used in the range pF 0 to pF 2.7:

$$\text{volume percentage of moisture} = \text{weight percentage of moisture} \times \frac{\text{ovendry weight of 100 cc}^3 \text{ volumetric sample}}{100}$$