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Soil quality — Determination of soil water content as a volume fraction using coring sleeves — Gravimetric method

Qualité du sol — Détermination de la teneur en eau du sol en fraction volumique, à l'aide de carottiers — Méthode gravimétrique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11461 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 5, *Physical methods*.

Soil quality — Determination of soil water content as a volume fraction using coring sleeves — Gravimetric method

1 Scope

This International Standard specifies a method for the gravimetric determination of soil water content as a volume fraction.

The method is applicable to all types of non-swelling or non-shrinking soils where coring sleeves can be used for sampling. It is not applicable to soils where stones, tough roots or other factors prevent collection of soil cores. It is used as a reference method (e.g. the calibration of indirect methods for determination of water content).

NOTE The determination of water content as a mass fraction is described in ISO 11465.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1

water content volume fraction

θ

volume of water evaporating from the soil when dried to constant mass at 105 °C, divided by the original bulk volume of the soil

NOTE The water content volume fraction is sometimes also referred to as “volumetric water content”.

2.2

constant mass

mass reached when during the drying process the difference between two successive weighings of the sample, after a drying interval of 4 h, does not exceed 0,1 % (mass fraction) of the last determined mass

NOTE Usually 16 h to 24 h is sufficient for drying most soils to constant mass, but certain soil types and large or very wet samples will require longer.

3 Symbols

m	mass, expressed in kilograms
V	volume, expressed in cubic metres
s_x	sample standard deviation of variable x
Δ_x	standard deviation of the errors in variable x
θ	water content volume fraction
ρ_w	density of water, expressed in kilograms per cubic metre ($\text{kg} \cdot \text{m}^{-3}$)

4 Principle

Soil samples of known volume are dried to constant mass at (105 ± 5) °C. The difference in the mass of the soil sample, before and after the drying procedure, is taken as a measure of the water content. The water content is calculated as a volume fraction.

NOTE Organic matter can oxidize during drying. This has no significant effect on the water content determined. However, drying at lower temperatures, e.g. 60 °C, can lead to significantly lower values of the water content. Hence, drying at a temperature lower than 105 °C is not recommended.

5 Apparatus

5.1 Drying oven, thermostatically controlled with forced air ventilation and capable of maintaining a temperature of (105 ± 5) °C. Differences in temperature between various positions in the oven shall be less than ± 5 °C.

NOTE By measuring the temperature at the centre of a sample during or directly after the drying procedure using a thin thermocouple with low thermal capacity, it is possible to determine whether the oven is working efficiently. These measurements should be carried out on dry samples, to prevent temperature differences due to evaporation.

5.2 Desiccator with an active drying agent.

5.3 Balance, capable of weighing accurately to within 0,1 % of the mass of the dried sample.

5.4 Coring sleeves, of known volume, fitted with water- and vapour-tight caps of known mass to prevent evaporation of water from the samples.

Each sleeve shall have a sharp cutting edge or shall be used with a holder with a sharp cutting edge. The volume of each coring sleeve shall be greater than 20 cm^3. The precise dimensions of the coring sleeves will depend on the goal of the investigation.

5.5 Pushing rod, for the coring sleeves.

5.6 Dishes of known mass, to support the soil in the coring sleeves while handling them in the laboratory.

6 Field sampling

6.1 General

For the direct determination of water content volume fraction, a sample of known volume is required and coring sleeves are therefore used for sample collection.

The size of the coring sleeves and the number of samples required will be governed by the objectives of the investigation and usually the need to represent the soil more generally; one should take into account the size of the structural elements of the soil and its variability.

Samples shall be collected, transported and stored so that their water content does not change from that at the time of sampling.

6.2 Sampling procedure

In the field, take the soil samples by pushing coring sleeves (5.4) into the soil either directly or using a holder. Extract each soil-filled sleeve carefully from the soil. Trim any soil protruding from the sleeve using a straight knife. Discard soil cores that are either compacted or incomplete. The pushing rod (5.5) may be used for sampling at depth. Cover both ends of the coring sleeves. Use water- and vapour-tight caps (5.4), in order to prevent evaporation of water during transport to the laboratory.

7 Procedure

CAUTION — With samples from contaminated soils, avoid any contact with the skin and use ventilation and extraction during the drying process to prevent contamination of the laboratory atmosphere and other samples.

7.1 Using the balance (5.3), determine the mass, m_{tot0}, of the soil-filled coring sleeve with caps as soon as possible after sampling, to prevent errors due to evaporation of soil water.

7.2 Remove the upper cap. Place a dish of known mass (5.6; or similar device) on the sleeve to support the soil. Turn over the sample and remove the other cover. Ensure that no soil remains on the caps. If necessary, transfer that soil to the soil in the coring sleeve. Place the coring sleeve with dish in the drying oven. Ensure that the oven is set to a temperature of 105 °C. Ensure that the water vapour can escape and that the temperature does not vary more than 5 °C throughout the oven. Let the sample dry for at least 16 h.

7.3 Take the soil-filled coring sleeve with dish out of the oven and place them in a desiccator (5.2) containing an active drying agent. Transport the desiccator to the balance (5.3). Determine the mass of the soil-filled coring sleeve with dish.

7.4 Replace the soil-filled coring sleeve with dish in the oven for an additional 4 h and repeat the drying-weighing procedure until the difference in two successive weighings does not exceed 0,1 % of the last determined mass of the dried sample, m_{tot1}.

8 Expression of results

Calculate the total mass of the field-wet soil, sleeve and dish:

$$m_{\text{tot2}} = m_{\text{tot0}} - m_{\text{cap}} + m_{\text{dish}}$$

where

m_{cap} is the mass of the caps, in kilograms;

m_{dish} is the mass of the dish, in kilograms;

m_{tot0} is the total mass of the field-wet soil, sleeve and caps, in kilograms;

m_{tot2} is the total mass of the field-wet soil, sleeve and dish, in kilograms.

The water content volume fraction is given by the equation:

$$\theta = \frac{m_{\text{tot2}} - m_{\text{tot1}}}{\rho_{\text{w}} \cdot V}$$

where

θ is the water content volume fraction;

m_{tot1} is the total mass of the oven-dry soil, sleeve and dish, in kilograms;

m_{tot2} is the total mass of the field-wet soil, sleeve and dish, in kilograms;

ρ_{w} is the density of water at soil temperature, in kilograms per cubic metre;

V is the volume of the coring sleeve, in cubic metres.

9 Accuracy and precision

9.1 General

In the procedure stated for the determination of volumetric water content, the main factors that may influence the water content measurement are sampling, transport, laboratory treatment and density of water.

9.2 Sampling

a) Compaction and/or disturbance of the sample may influence the measurement. Various factors including the compressibility of the soil, the presence of stones and the sharpness of the cutting edge influence whether a sample is disturbed and/or compacted to some extent during sampling. These factors may cause variable and/or systematic errors in time and space. The variable (i.e. coincidental) error component occurs in time and space (t,x) with respect to m_{tot2}: $\Delta_{m\text{tot2}}\,(t,x)$. Systematic errors may occur and if possible, a correction should be established for these. The uncertainty in this correction should then be applied as the final systematic error, hence: corr. $\pm\,\Delta_{m\text{tot2}}$.

b) A deviation in the sample volume due to imperfect cutting of the sample results in a variable error of the type $\Delta_V\,(t,x)$.

c) Poor precision of the volume of the sample sleeve may influence the measurement. One should establish a correction for this effect, hence: corr. $\pm\,\Delta_V$.

9.3 Transport

Evaporation of water from moist soil samples or sorption of water from the air by relatively dry samples may occur due to poor closure of the coring sleeve caps and/or a too long period for transport or storage. The susceptibility of the sample to such water content changes is influenced by its water content. It results in a correction as in 9.2 a), hence: corr. $\pm\,\Delta_{m\text{tot2}}$.

9.4 Laboratory analysis

a) Poor precision of the weighing balance results in a variable error in both weighings, hence: $\Delta_{m\text{tot1}}\,(t,x)$ and $\Delta_{m\text{tot2}}\,(t,x)$.

b) Weighing errors in the mass of dishes and caps result in systematic errors in m_{tot2}, hence corr. $\pm\,\Delta_{m\text{tot2}}$.

c) Loss of sample mass, due to soil grains sticking to the caps when removing them, results in a variable error in m_{tot1}, hence $\pm\,\Delta_{m\text{tot1}}\,(t,x)$.

d) Volatilization of substances other than water on heating at 105 °C may influence the measurement. In soils where this process is important, establish a correction for the effect, hence: corr. $\pm\,\Delta_{m\text{tot2}}$.

e) Sorption of moist air, due to too long a time between removing the sample from the desiccator and the second weighing, also calls for a correction: corr. $\pm\,\Delta_{m\text{tot1}}$.

9.5 Density of water

A deviation in water density as a consequence of temperature differences between the field and the laboratory results in a correction of the type corr. $\pm\,\Delta_{\rho\text{w}}$.

After estimation of the standard deviation of the respective error sources, their propagation in the water content can be estimated with the following formula:

$$s_\theta = 3\sqrt{\left(\frac{1}{\rho_\text{w}V}\right)^2\left(s^2_{m\text{tot1}} + s^2_{m\text{tot2}}\right) + \left(\frac{\theta}{\rho_\text{w}V}\right)^2\left(V^2 s^2\rho_\text{w} + \rho^2_\text{w}s^2_V\right)}$$

where

s_θ	represents the standard deviation of the errors influencing the water content volume fraction;
$s_{m\text{tot1}}$	represents the standard deviation of the errors influencing m_1;
$s_{m\text{tot2}}$	represents the standard deviation of the errors influencing m_2;
$s_{\rho\text{w}}$	represents the standard deviation of the errors influencing ρ_w;
s_V	represents the standard deviation of the errors influencing V.

In the final results one may distinguish between the (total) variable component $\Delta_\theta\,(t,x)$ and the (total) systematic component Δ_θ.

General guidelines for the actual magnitude of specific error sources cannot be given since they entirely depend on sampling and laboratory practice. However, errors can be reduced to a minimum when the guidelines in this International Standard are followed strictly, and when samples are treated as quickly as possible in order to prevent water losses and gains. Under ideal field circumstances and a strict treatment of the samples, an accuracy better than 0,005 $\text{m}^3 \cdot \text{m}^{-3}$ may be attained.

10 Test report

The test report shall include at least the following information:

a) reference to this International Standard;

b) an accurate description of the sampling location and depth;

c) the date of field sampling;

d) the mass of the soil sample used for the determination;

e) the calculated water content as a volume fraction;

f) details of any operations not specified in this International Standard, or regarded as optional, as well as any factor which may have affected the results.

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