

2 Determination of Chemical and Physical Soil Properties

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2.1 Soil Dry Mass and Water Content

■ Introduction

Objectives. Measures of soil water content and dry mass are needed in practically all types of soil studies, e.g., determination of water holding capacity, plant available water, infiltration, pore size distribution, permeability. With respect to soil microbial processes and biological soil remediation, determination of optimum water content for measurement of microbial parameters and activity, as well as determination of soil permeability for estimation of the success of in situ remediation, is of essential importance.

Principle. Soil samples are dried at $105 \pm 5^\circ\text{C}$ until mass constancy is reached. The differences in masses before and after drying are a measure for the water content of soils. The water content is calculated on gravimetric ($g_{\text{water}}/g_{\text{soil}}$) or on volumetric basis ($\text{cm}^3_{\text{water}}/\text{cm}^3_{\text{soil}}$). The method described below can be used for disturbed and undisturbed (sampling of soil using coring sieves) soil samples. It is a direct laboratory measurement. The procedure described can be used for the determination of dry mass on a mass basis (ISO 11465 1993).

Theory. Under natural conditions all soils contain water. The amount of water can be very low in air-dried soils. As a convention the total water content and dry mass of soils are measured after drying at 105°C (ISO 11465 1993). Thus, the water content of a soil is given as percent by weight or volume of oven-dried soil. Water which is removed at higher temperatures is not included in the definition of soil water. The soil water content can be determined with direct and indirect methods. Direct methods are more precise but time consuming. Indirect methods are mainly used for continuous determination of water contents in the field. The most appropriate indirect method is the time domain reflectometry (TRD) method (Topp et al. 2000). The optimum water content for microbial processes is in

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the range of 40–60% of maximum water-holding capacity (WHC, Sect. 2.2), or corresponds to the water content that is held in soil at suction pressures of -0.01 to -0.031 MPa.

■ Equipment

- Drying oven, thermostatically controlled with forced air ventilation and capable of maintaining a temperature of 105 ± 5 °C
- Desiccator with an active drying agent
- Analytical balance, accuracy 1 mg
- Container (moisture box, 25–100 mL) with lid, made of waterproof material that does not adsorb moisture, capacity 25–100 mL for air-dried soil samples and at least 100 mL for field-moist soil samples
- Spoon

■ Procedure

Air-Dried Soil Samples

1. Dry container with lid at 105 ± 5 °C and then cool it, with the lid closed, in a desiccator for at least 45 min. Determine the mass (m_o) of the closed container with an accuracy of ± 1 mg.
2. Transfer 10–15 g of air-dried soil to this container using a spoon.
3. Determine the mass (m_1) of the closed container and soil with an accuracy of ± 1 mg.
4. Dry the container and soil in an oven at 105 °C until constant mass is achieved. Dry the lid at the same time.
5. Cool the container with the lid closed in a desiccator for at least 45 min.
6. Remove the container from the desiccator and immediately determine the mass (m_2) of the closed container containing the oven-dried soil with an accuracy of ± 10 mg.

Field-Moist Soil Samples

1. Place the soil on a clean surface that does not absorb moisture (e.g., a glass plate) and mix well. Remove particles with a diameter > 2 mm.
2. Dry container with lid at 105 ± 5 °C and then cool it, with the lid closed, in desiccator for at least 45 min. Determine the mass (m_o) of the closed container with an accuracy of ± 1 mg.
3. Transfer 30–40 g of soil to this container using a spoon.

4. Determine the mass (m_1) of the closed container and soil with an accuracy of ± 10 mg.
5. Dry the container and soil in an oven at 105°C until constant mass is achieved. Dry the lid at the same time.
6. Cool the container with the lid closed in a desiccator for at least 45 min.
7. Remove the container from the desiccator and immediately determine the mass (m_2) of the closed container containing the oven-dried soil with an accuracy of ± 10 mg.

■ Calculation

Calculate the dry mass content (w_{dm}) or water content ($w_{\text{H}_2\text{O}}$) on a dry mass basis expressed as percentages by mass to an accuracy of 0.1% (m/m) using the following equations:

$$w_{\text{dm}} = \frac{m_2 - m_0}{m_1 - m_0} \times 100 \quad (2.1)$$

$$w_{\text{H}_2\text{O}} = \frac{m_1 - m_2}{m_2 - m_0} \times 100 \quad (2.2)$$

m_0 mass of the empty container with lid (g)

m_1 mass of the container with air-dried soil or field-moist soil (g)

m_2 mass of the container plus oven-dried soil (g)

■ Notes and Points to Watch

- With contaminated soil samples, special measures must be taken. Avoid any contact with the skin. Special measures must be taken during the drying process in order to prevent contamination of the laboratory atmosphere. The procedures must be performed as quickly as possible to prevent evaporation.
- In general decomposition of organic material can be neglected at temperatures up to 105°C . However, for soil samples with a high organic matter content ($> 10\%$ m/m) the method of drying should be adapted by drying to a constant mass at 50°C .
- Some minerals similar to gypsum lose chemically combined water at a temperature of 105°C .
- If volatile organic substances are present, the method will not give a reliable determination of the water content.

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