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Soil quality — Soil water and the unsaturated zone — Definitions, symbols and theory

Qualité du sol — Eau du sol et zone non saturée — Définitions, symboles et théorie

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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.

The main task of technical committees is to prepare International Standards. 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.

ISO 15709 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 1, *Evaluation of criteria, terminology and codification*.

Introduction

This document provides background information for soil physical investigations of the unsaturated zone. It enables a better understanding of the International Standards used for the determination of soil properties and the status of the soil water (e.g. ISO 10573, ISO 11267, ISO 11274, ISO 11275, ISO 11461, etc.).

Soil comprises an intimate mix of liquids (water), gases and biota within a solid porous matrix. Water is a particularly important soil component. The state of water in a soil changes continually in response to modifications of hydraulic conditions caused by inputs of water (infiltration, upward capillary flux) and/or losses due to evapotranspiration and drainage. Saturated soils generally have a water content of 30 % to 50 % of the total soil volume. In the upper unsaturated layers quantities are smaller, but water content fluctuation with time is marked, from less than 10 % to more than 30 % by volume, depending on the soil and environment. In some cases, for example after heavy rain, in early spring, saturated conditions should also appear.

Knowledge of the quantity of water present in soil is useful. Most soil water is held in pore spaces, although certain soils, e.g. those dominated by smectites or similar minerals, can hold considerable quantities of non-easily-removable water adsorbed on mineral particle surfaces. The size and shape of a pore and the amount of water present within it determine how strongly water is held there and how easily water may flow through it. Water flow occurs in response to potential energy gradients. Therefore information as to the water retention and hydraulic conductivity properties of a soil, as well as field soil water potentials, gives much fuller understanding of soil water conditions. Which of these soil properties should be determined for a particular project will depend on the nature of the problem being studied.

Soil quality can only be defined in terms of the intended use of a soil; e.g. soil water conditions favourable for a natural wetland are not appropriate for grain production, except rice. Soil quality is particularly relevant to environmental issues as well as agricultural production. Soil water characteristics should be known, especially those where the emphasis is on

a) the availability of soil water to sustain plant growth,

b) the maintenance or modification of shallow water table conditions,

c) soil contamination caused by point, line or diffuse sources of pollution.

In addition, soil water is significant to the quality of surface and ground waters. Soil water movement is often the mechanism by which soluble pollutants are transported to surface and ground waters.

Water plays an essential role in the life of plants, directly as such and in transporting nutrients from the soil to and through the plant; it is also crucial to seed germination. Agricultural production depends upon sustaining a supply of water to crops so that water stress is minimized. Excess soil water is problematic, however, for if much of the available pore space is water-filled, lack of oxygen may limit root growth, and in extreme cases lead to plant death. Soil water availability is often significant in determining the character of the natural vegetation which grows in a given location. Maintenance of a given plant community may depend upon regular periods of water stress and/or water excess. Plant water use is driven by the atmospheric evaporative demand. The amount of water available for transpiration is determined by the physical quality of the soil, which can be quantified by several parameters including the soil water content, the water retention curve and the hydraulic conductivity of the unsaturated zone.

In many cases, it is the soil cover which determines recharge rates to the aquifer, as well as discharge due to plant water use, and hence maintenance of water levels. Assessment of the agricultural and environmental impact of shallow ground-water extraction is facilitated by use of soil physical and hydrogeological methods. Measurements of pore-water potentials in both the saturated and unsaturated zones, and of hydraulic conductivities, are essential to understand the direction and rate of water movement.

Pollutants, whether due to diffuse, point or line contamination, are usually transported through soil by water flow. Pollutants are usually transported from the surface by water flow. Many processes influence the fate of a particular pollutant as it moves into and through the soil. Identification of water flow pathways and flowrates is essential to determine pollutant travel times and the possibility of degradation or sorption related retardation. Water and pollutants which move beyond the unsaturated zone cause surface and/or ground water pollution. Soil physical investigations are therefore an important part of pollution studies.

Soil water is relevant to the investigations of several branches of the various soil and earth sciences, including agriculture, forestry, environmental studies, hydrology, hydrogeology and civil engineering. Each has developed its own methods of investigation, many of which overlap. In considering soil water and soil quality for environmental and agricultural purposes, the aim should be satisfactory integration of methodologies to permit the evaluation of soil quality conditions. It is important that organizations dealing with soil quality should have access to standardized methods of soil water measurement, and a standardized set of definitions, units and symbols, so that reliability of determinations is assured, and comparisons with results from elsewhere are possible.

The simplified theory of the physics of soil water in the unsaturated zone in clause 4 is broadly in line with references [3] and [5].

Soil quality — Soil water and the unsaturated zone — Definitions, symbols and theory

1 Scope

This International Standard gives a simplified theory of the physics of soil water in the unsaturated zone and defines a set of terms, quantities, units and symbols used in the field of soil physics investigation of the unsaturated zone.

This International Standard is applicable only to standards on soil physical investigations of the unsaturated zone (including swelling soils) elaborated within ISO/TC 190. This International Standard specifically excludes macropore flow.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions, based on [8], [9] and [10], apply.

2.1 General terms

2.1.1
water content
φ_w
⟨volume fraction⟩ 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 Water content is dimensionless.

2.1.2
water content
w_w
⟨mass fraction⟩ mass of water evaporating from the soil when dried to constant mass at 105 °C, divided by the dry mass of the soil

NOTE Water content is dimensionless.

2.1.3
soil water retention characteristic
$h_\mathrm{m}(\varphi)$
relation between soil water content and soil matric head of a given soil (sample)

2.1.4
hydraulic conductivity
K
factor of proportionality between the soil water flux density and the hydraulic gradient in Darcy's equation, assuming isotropic conditions, i.e. $v = -K\nabla h_\mathrm{h}$

NOTE Hydraulic conductivity is expressed in metres per second $(\mathrm{m \cdot s^{-1}})$.

2.2 Soil water potential and equivalents

2.2.1 Potential

NOTE Potential is expressed in joules per kilogram $(\mathrm{J \cdot kg^{-1}})$.

2.2.1.1
total potential
e_t
⟨of soil water⟩ amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water from a pool of pure water, at a specified elevation and at atmospheric pressure, to the soil water at the point under consideration, divided by the mass of water transported

2.2.1.2
pneumatic potential
e_a
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at atmospheric pressure and at the elevation of the point under consideration, to a similar pool at an external gas pressure of the point under consideration, divided by the mass of water transported

2.2.1.3
gravitational potential
e_g
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at a specified elevation and the external gas pressure of the point under consideration, to a similar pool at the elevation of the point under consideration, divided by the mass of water transported

2.2.1.4
matric potential
e_m
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at the elevation and the external gas pressure of the point under consideration, to the soil water at the point under consideration, divided by the mass of water transported

2.2.1.5
osmotic potential
e_o
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of pure water from a pool at the elevation and external gas pressure of the point under consideration, to a similar pool containing water, identical in composition to the soil water, divided by the mass of water transported

2.2.1.6
pore water potential
tensiometer potential
e_p
sum of matric and pneumatic potentials

NOTE In most cases e_a is zero, in which case $e_\mathrm{p} = e_\mathrm{m}$.

2.2.1.7
hydraulic potential
e_h
sum of matric, pneumatic and gravitational potentials

NOTE In most cases $e_\mathrm{a} = e_\mathrm{o} = 0$, in which case $e_\mathrm{h} = e_\mathrm{t}$.

2.2.2 Pressure equivalent

NOTE Pressure is usually measured with a tensiometer; it is expressed in pascals (Pa).

2.2.2.1
pressure
p
pressure equivalent of soil water potential

NOTE Subscripts as for potentials.

2.2.2.2
total pressure
p_{t}
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water from a pool of pure water, at a specified elevation and at atmospheric pressure, to the soil water at the point under consideration, divided by the volume of water transported

2.2.2.3
pneumatic pressure
p_{a}
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at atmospheric pressure and at the elevation of the point under consideration, to a similar pool at an external gas pressure of the point under consideration, divided by the volume of water transported

2.2.2.4
gravitational pressure
p_g
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at a specified elevation and the external gas pressure of the point under consideration, to a similar pool at the elevation of the point under consideration, divided by the volume of water transported

2.2.2.5
matric pressure
p_{m}
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of water identical in composition to the soil water from a pool at the elevation and the external gas pressure of the point under consideration, to the soil water at the point under consideration, divided by the volume of water transported

2.2.2.6
osmotic pressure
p_{o}
amount of work that must be done in order to transport, reversibly and isothermally, an infinitesimal quantity of pure water from a pool at the elevation and external gas pressure of the point under consideration, to a similar pool containing water identical in composition to the soil water divided by the volume of water transported

2.2.2.7
pore water pressure
p_{p}
sum of matric and pneumatic pressures

NOTE 1 In most cases p_{a} is zero, in which case $p_{\mathrm{p}} = p_{\mathrm{m}}$.

NOTE 2 Usually the pore water pressure is measured with a tensiometer.