143ESP - Soil Physics for Engineers

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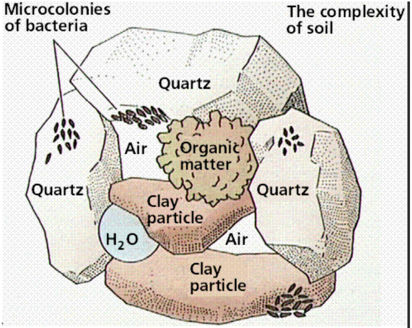
all materials at
storm.fsv.cvut.cz/.../soil-physic-for-engineers

Soil Science

Soil Science deals with soil as a natural resource on the surface of the earth including soil formation, classification and mapping; physical, chemical, biological, and fertility properties of soils; and these properties in relation to the use and management of soils.



Source http://www.cartage.org.lb

Pedology soil genesis, morphology, classification, structure, texture,...
Soil chemistry
Soil Biochemistry
Soil physics studies the properties and processes of materials in the soil from the physical description of soil particles, soil aggregates, into the storage and transport phenomena of water, gas, heat, and solute in soil.

- soil mechanics
- soil hydrology(vadose zone hydrology or hydropedology)

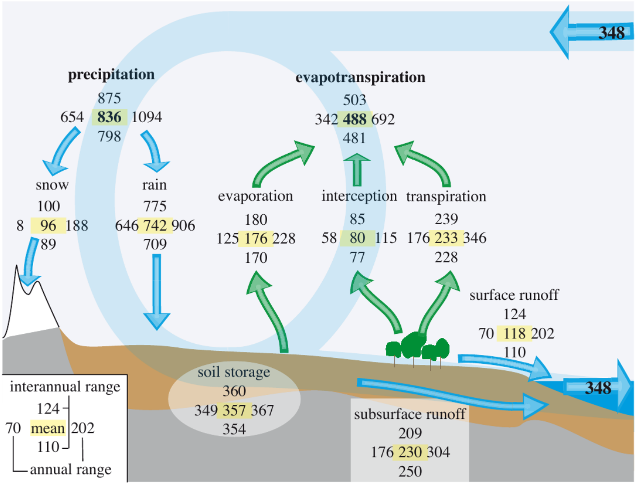


Figure 1.1. Schematic of global terrestrial water cycle [after *Dirmeyer et al.* 2006]. The numbers have been calculated from simulations of the 10-year period 1986-1995 by 15 different global circulation models. In addition to the average numbers for the entire period (yellow rectangles), the range of fluctuations within and between years is indicated. Fluxes are in mm y^{-1}, soil storage is in mm. The numbers represent averages over the continental area, excluding Antarctica. With an area of $134 \cdot 10^6$ km^2, a flux of 1 mm y^{-1} corresponds to a flow of 134 km^{3}y^{-1}.

Covered topics

- Theory and application of water and miscible substances transport in the soil.
- **Heterogeneity and variability of soil hydraulic characteristics**
- Conservative transport, advection, dispersion, characteristics of the dispersion
- Description of chemical reactions, equilibrium and kinetic sorption.
- **Modeling of transport process.**

12 practicals

- Soil properties (today)
- Soil hydraulic properties and transport physics (1/3)
  - retention curve, unsaturated hydraulic conductivity
  - transport governing equations
- 1D modeling of water and miscible substances transport (1/3)
- 2D and 3D modeling of water and miscible substances transport (1/3)

Conditions for passing the practicals

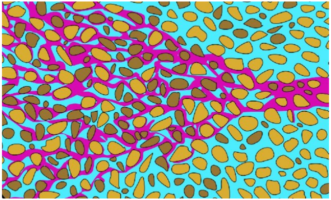
- Complete and hand in assignments in practicals.
- Hand in two larger homework's.
- Presence at practicals - a maximum of 3 absences are allowed (assignments have to be finished anyway).

Hand in your work at the end of each practical or via email jakub.jerabek@fsv.cvut.cz with subject: **143ESP**

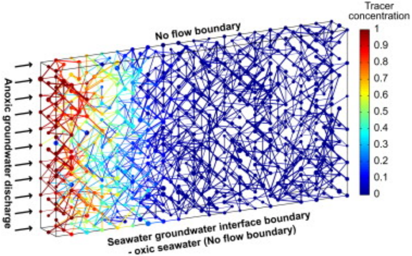
Soil characteristics

Soil characteristic: continuum approach

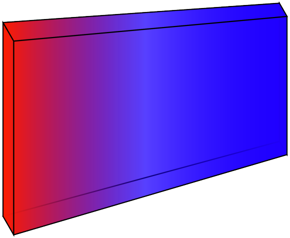
Real porous media (Li et al., 2019)



Discrete approach



Continuous approach



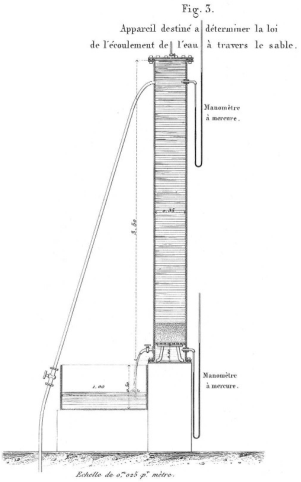
Soil characteristics

(dry) Bulk density:	$\rho_b = \frac{m_s}{V_T}$	$[kg/m^3,\ g/cm^3]$
(wet, actual) Bulk density:	$\rho = \frac{m_T}{V_T}$	$[kg/m^3,\ g/cm^3]$
Density of soil particles:	$\rho_s = \frac{m_s}{V_s}$	$[kg/m^3,\ g/cm^3]$
Porosity:	$n = \frac{V_p}{V_T}$	$[-, \%]$
Volumetric water content:	$\theta = \frac{V_w}{V_T}$	$[m^3/m^3, cm^3/cm^3]$
Saturated VWC:	$\theta_s = \frac{V_w}{V_T}$	$[m^3/m^3, cm^3/cm^3]$
Residual VWC:	$\theta_r = \frac{V_w}{V_T}$	$[m^3/m^3, cm^3/cm^3]$
Degree of saturation:	$S_w = \frac{V_w}{V_p}$	$[-, \%]$
(Effective VWC)	(θ_e)	

m_s	Weight of dried soil
V_T	Volume of sample
V_s	Volume of soil particles in the sample
V_p	Volume of pores in the sample
V_w	Volume of water in the sample

Darcy's law

- Henry Darcy (1856)
- Water infiltration through sand column in the water supply system in the city of Dijon



Darcy's law

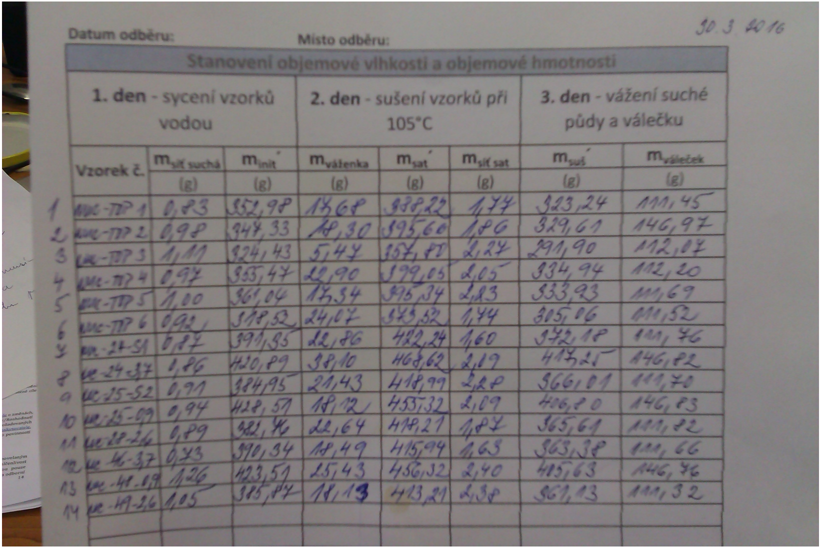
$$q = -K_s \frac{dH}{dl}, \quad v = q/n$$

q - darcy flux $[m/s]$
K_s - saturated hydraulic conductivity $[m/s]$
H - pressure gead $[m]$
l - length $[m]$
v - mean porous flow velocity $[m/s]$

You collected several soil undisturbed samples in the field. Samples were taken from several depths in the soil profile. The lab fills in a form with your results. You need to:

1. calculate soil characteristics (θ, ρ_b, n) based on the data in the form (find form in figure 1),
2. plot calculated soil characteristics as a function of depth.

HINT: Height of the cylinder is 6 cm. Diameter of the cylinder is 5.5 cm.



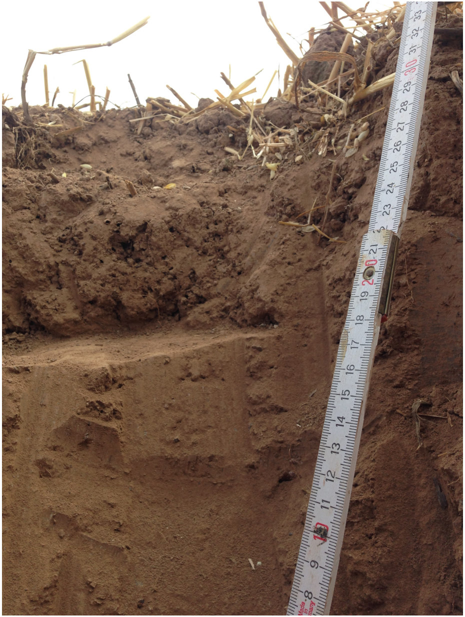
Datum odběru: Místo odběru: 30. 3. 2016

	Stanovení objemové vlhkosti a objemové hmotnosti							
		1. den - sycení vzorků vodou		2. den - sušení vzorků při 105°C			3. den - vážení suché půdy a válečku	
	Vzorek č.	$m_{síť\ suchá}$ (g)	m_{init} (g)	$m_{váženka}$ (g)	m_{sat} (g)	$m_{síť\ sat}$ (g)	$m_{suš}$ (g)	$m_{váleček}$ (g)
1	ue-TTP 1	0,83	352,98	17,68	338,22	1,77	323,24	111,45
2	ue-TTP 2	0,98	347,33	18,30	395,60	1,86	329,61	146,97
3	ue-TTP 3	1,11	324,43	5,47	357,88	2,27	291,90	112,07
4	ue-TTP 4	0,97	355,47	22,90	399,05	2,05	334,94	112,20
5	ue-TTP 5	1,00	361,04	17,34	395,34	2,23	333,93	111,69
6	ue-TTP 6	0,92	318,52	24,07	373,52	1,44	305,06	111,52
7	ue-24-51	0,87	391,35	22,86	422,24	1,60	372,18	111,76
8	ue-24-37	1,86	420,89	38,10	468,62	2,19	417,25	146,82
9	ue-25-52	0,91	384,95	21,43	418,99	2,28	366,01	111,70
10	ue-25-09	0,94	428,51	18,12	455,32	2,09	406,80	146,83
11	ue-28-26	0,89	382,46	22,64	418,21	1,87	365,61	111,82
12	ue 46-37	0,73	390,34	18,49	415,94	1,63	363,38	111,66
13	ue-48-09	1,26	423,51	25,43	456,32	2,40	405,63	146,76
14	ue-49-26	1,05	385,87	18,13	413,21	2,38	361,13	111,32

Figure 1: Form with weighed samples.

data at storm.fsv.cvut.cz/.../soil-physic-for-engineers

Figure 2: Samples in dryer



Piezometric data at locations A and B with mutual distance of 500 m are shown in the table below. Confined groundwater table is in homogeneous material with hydraulic conductivity of 0.05 cm/s and porosity of 30%

1. Calculate the hydraulic gradient between the piezometers and define the direction of the flow.
2. Infer the time that it takes for the water to flow between piezometer A and B (in years)

Piezometer	altitude	GWL bellow land surface
A	120 m	33 m
B	110 m	25 m