ORGANIZERS:
70 LAT UNIWERSYTET ROLNICZY W KRAKOWIE
Faculty of Environmental Engineering and Land Surveying University of Agriculture in Krakow
SUA Slovak University of Agriculture in Nitra
SUA·FHLE Faculty of Horticulture and Landscape Engineering

HONORARY PATRONAGE:
MINISTERSTWO INFRASTRUKTURY
MAŁOPOLSKA Patronat Honorowy: Witold Kozłowski, Marszałek Województwa Małopolskiego
PATRONAT HONOROWY STAROSTA WIELICKI ADAM KOCIOŁEK
PAN POLSKA AKADEMIA NAUK
GŁÓWNY URZĄD GEODEZJI I KARTOGRAFII
Państwowe Gospodarstwo Wodne Wody Polskie
SITWM

26th INTERNATIONAL SCIENTIFIC CONFERENCE
ENVIRO 2023
PROBLEMS OF ENVIRONMENTAL PROTECTION AND DEVELOPMENT
21 – 23 June 2023
KRAKÓW – WIELICZKA

The EIS technique for tracing the changes of water content in selected practical use cases

Technika EIS do śledzenia zmian zawartości wody w wybranych praktycznych zastosowaniach

Jana Pařílková
Brno University of Technology

MEDIA PATRONAGE: DZIENNIK POLSKI, TVP3 KRAKÓW
GOLD SPONSORS: CarboHort, Pietrucha Established 1960
SILVER SPONSORS: AGROMAX, inora, SEEDiA, plantiCo

MONITORING OF POROUS MATERIAL PROPERTIES IS COMPREHENSIVE PROBLEM

What we want to monitor?

Morphology of streambed, Bottom morphology of basin, pond, dike, dam, wood, masonry, meat …

Where we want to monitor?

In laboratory or in real conditions?

What we know about the monitoring site?

Have we made geophysical prospecting? How much do we know the site, the process …?

About what are we interesting in?

Are we interesting in sediment transport or accumulation, in sediment movement, in influence of water velocity to life in biotope, in locality? Are we interesting in erosion processes, movement of water level, studying of groundwater flow, seepage through dike, absorbency of materials …?

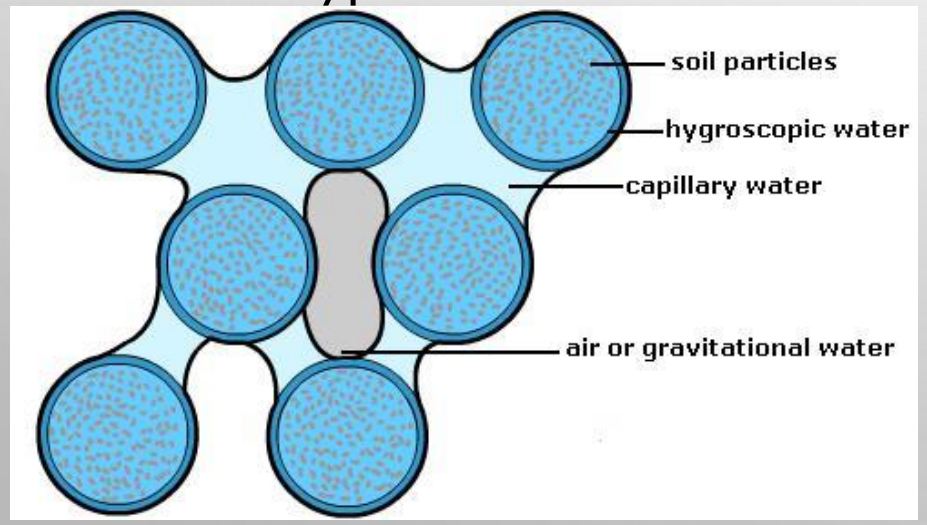
Which methods is possible to use?

Direct or indirect, contact or contactless and so on.

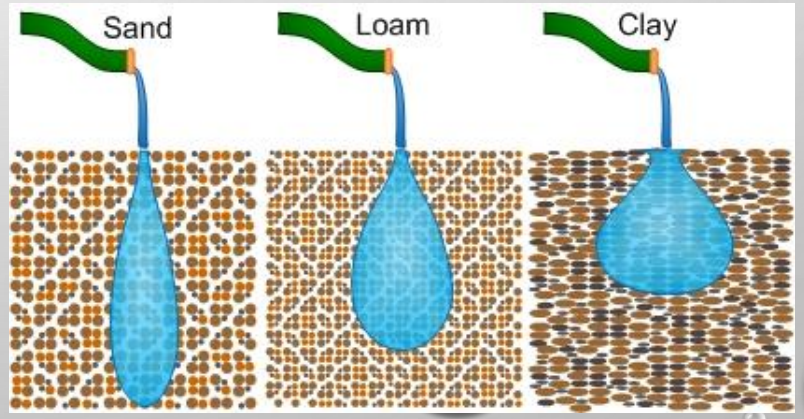
ANSWER TO THESE QUESTIONS FROM THE PERSPECTIVE OF THE EIS

- INDIRECT MONITORING METHOD – ELECTRICAL IMPEDANCE SPECTROMETRY (EIS) WAS USED.
- NEW MONITORING APPARATUS (DEVICE, PROBE, USER'S SOFTWARE) WAS DEVELOPED AND USED.
- THE TESTS WAS REALIZED IN LABORATORY AND IN REAL CONDITIONS SOLVING PROJECTS OF GA CR AND PROJECTS IN THE INTERNATIONAL PROGRAM EUREKA.

Three main types of soil water



E.g. hydraulic conductivity of unsaturated soil is about 3 or 4 levels smaller than in saturated soil.



EUREKA PROGRAMME

www.eurekanetwork.org www.eurostars-eureka.eu

- Eureka was established in 1985 as an agreement between 18 countries and the European commission to promote competitiveness and market integration and to encourage international cooperation in research and development.
- Since then, EUREKA has expanded to more than 45 countries (in Europe and beyond) that share the same goals and provide national/regional funding to organizations (at least two foreign partners) that apply through its programs.
- EUREKA has tailored programs to best support international industry-led research and development. These offer flexibility for international project partners within and outside the eureka network (network projects and Globalstars), support projects with leading companies in the field (Clusters), enable innovative smes to aim higher (Eurostars), support research and business activities on new markets (Innowwide).
- One of the fundamental principles of eureka is that project creation is bottom-up; organizations participating in eureka projects are free to define their research and development prior to application or even during project development.

CZECH REPUBLIC

MINISTRY OF EDUCATION
YOUTH AND SPORTS

MINISTRY OF EDUCATION, YOUTH AND SPORTS

ING. KLÁRA MUSILOVÁ

NATIONAL PROJECT COORDINATOR

klara.musilova@msmt.cz

https://www.msmt.cz/vyzkum-a-vyvoj-2/inter-excellence-ii-2021-2029

The Czech Republic implements the aforementioned projects within the framework of the Inter-Excellence program, specifically the Inter-Eureka sub-programme and the Eurostars program. The new INTER-EXCELLENCE II program (2021-2029) will include three sub-programs INTER-ACTION, INTER-COST, INTER-EUREKA (from May 24 to July14, 2023 is possible the project INTER-EUREKA submit, the results of the competition will be known by the end of the year).

INTER-EXCELLENCE

INTER-EUREKA

OUR EUREKA PROJECTS E!3838, E!4981 AND E!7614

- EUREKA projects must meet the following characteristics:
  civil purpose,
  international cooperation between organizations in two or more countries,
  research and development of a new product, process or service,
  market oriented, where participating organizations decide the focus of their research.

The first Z-meters were produced with the financial support of the Grant Agency of the Czech Republic. Next in the EUREKA program.

Z-meter 1	Z-meter 2

Needs converter $12V_{=}$ /230 $V_{\approx}$ and battery $12V_{=}$

- E!3838 – 2007-2009;
- E!4981 – 2010-2012;
- E!7614 – 2013-2016
  with sustainability to the 2021.

E!3838

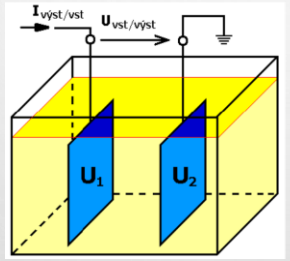
Z-meter IIA

Technical parameters

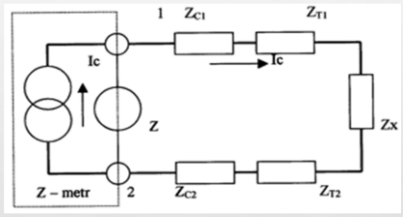
Internal switcher, 8 boards with 16 channels, Internal battery 12V=, PC, CF, mobile net, work signalization, two or four wire connection of the probes.

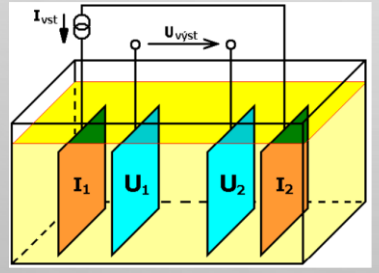
USER'S PROGRAM

Board 4						
Channel	Ug	Un	Ux0	Ux90	Rp	Xp
13	26016	12142	12610	1172	106	586
13	26016	12141	12612	1177	106	584
13	26020	12145	12614	1180	106	583
13	26023	12142	12614	1182	106	582
13	26022	12146	12617	1184	106	581
13	26025	12147	12617	1184	106	581
13	26026	12147	12616	1186	106	580
13	26025	12119	12648	1186	107	583
13	26025	12121	12649	1187	107	582
13	26026	12122	12649	1189	107	582

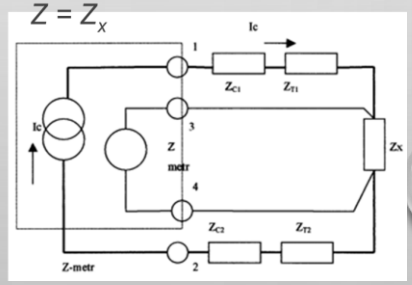


$$Z = Z_x + Z_{C1} + Z_{C2} + Z_{T1} + Z_{T2}$$

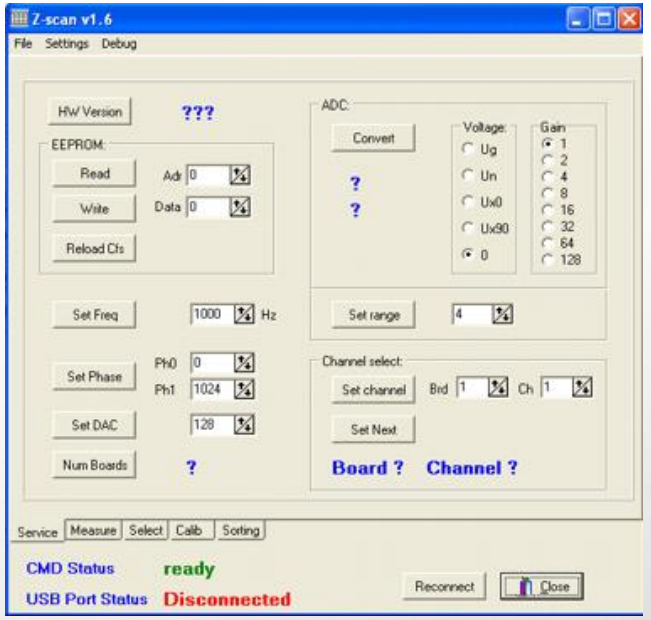


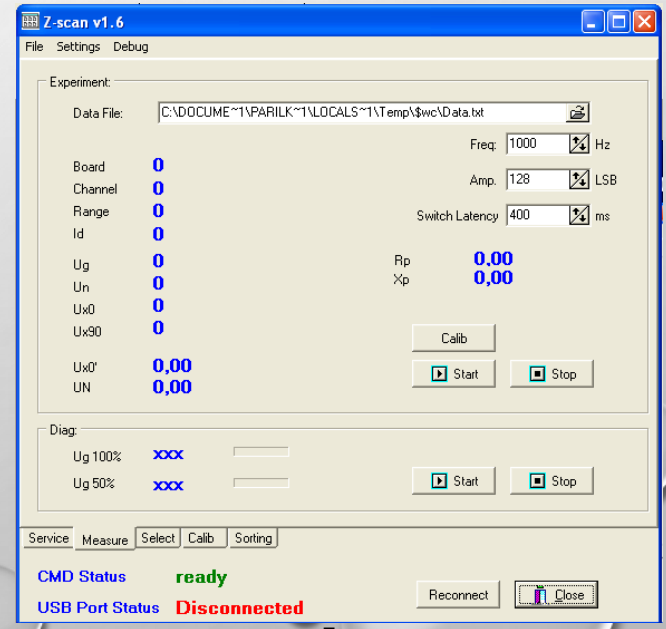


$$Z = Z_X$$



Functions, Menu





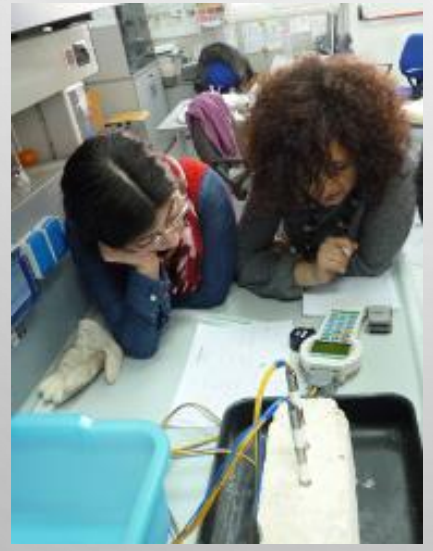
E!4981

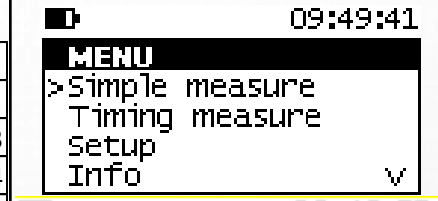
Z-meter III

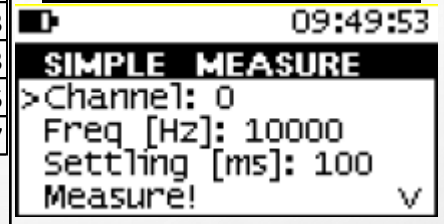
USER'S PROGRAM

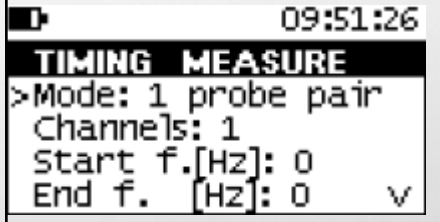
Functions, Menu

#Start at 24.3.2022 11:09:31							
No	f [Hz]	date [dd.r	time [hh:r	ch	range	Rx [ohm]	Xx [ohm]
1	8000	24.3.2022	11:09:32	0	1	312.5	-14.3
1	8000	24.3.2022	11:09:33	1	1	500.6	-35.4
1	8000	24.3.2022	11:09:34	2	1	502.3	-34.3
1	8000	24.3.2022	11:09:35	3	1	425.7	-22.3
1	8000	24.3.2022	11:09:36	4	1	265.8	-11.5
1	8000	24.3.2022	11:09:37	5	2	4028.4	-1997









Main menu

Simple measure

Simple measurement – it will make a single measurement of a value on a given channel

Timing measure

Timing measurement – it will measure values of impedance on a selected number of channels. Measurement can be repeated N times with a set period.

Measurement results are stored in a data file the name of which is entered before measurement starts.

Setup

Setting of general items (calibration, time, date, backlight of display, etc.).

Info

Information about the device (version, battery, licence)

Service

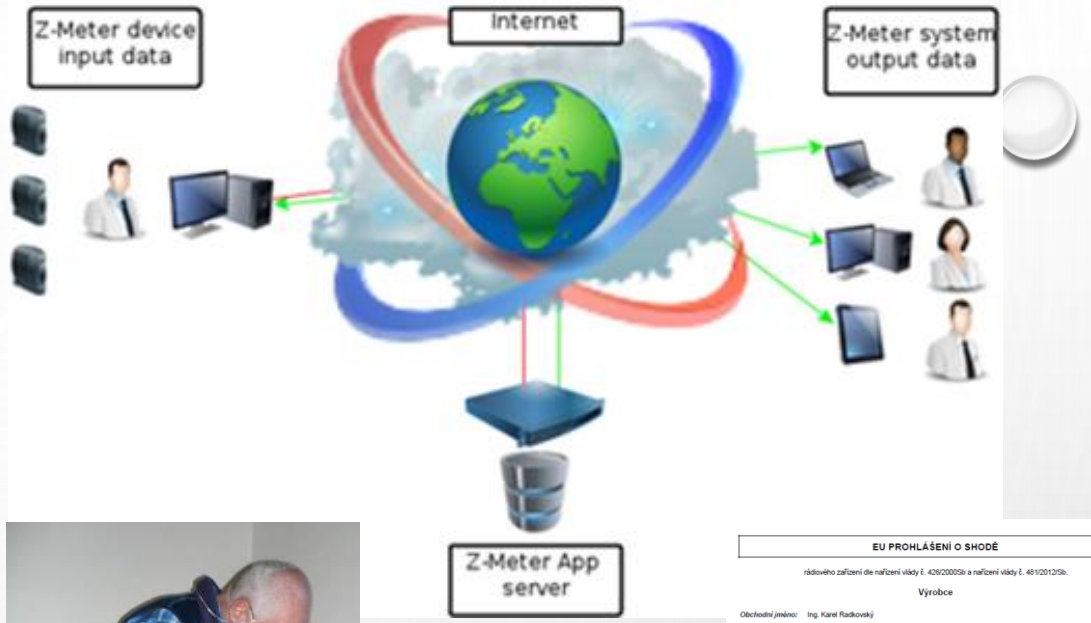
Service function – nothing is stored in the setup. After turning off and on the device, all changes from this menu will be set into the initial setup.

Switch off

To turn the device off.

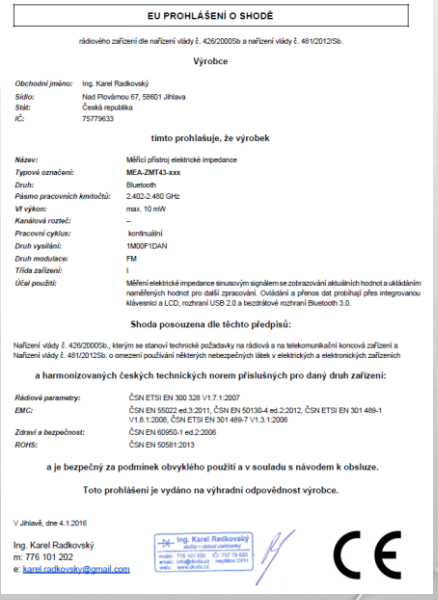
E!7614

Z-meter IV



safety statement

EU declaration of conformity



Control tests and reports on electrical parameters of the device Z-meter IV should be given time to time because the unit is used in the landscape.

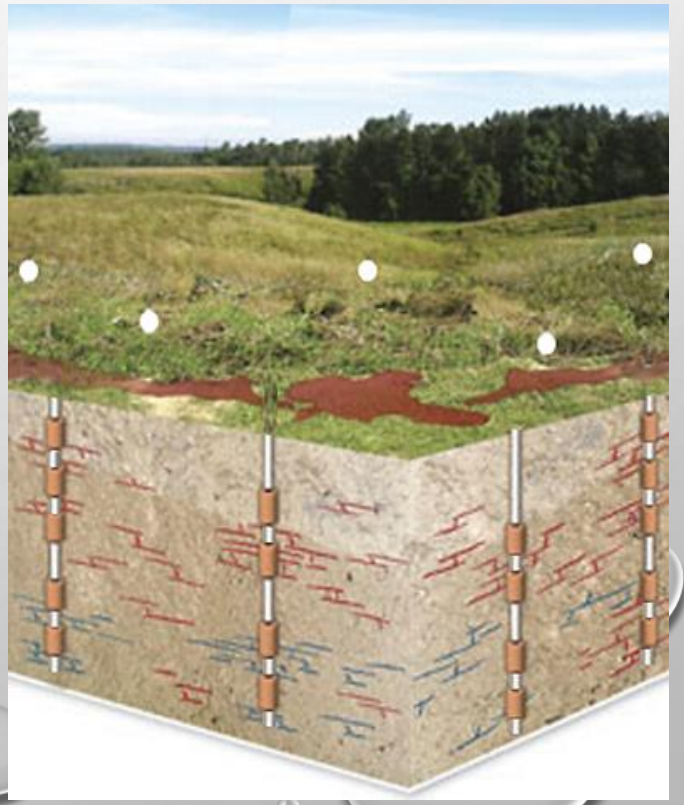
PARAMETERS OF THE DEVICES

Parameter	Z-meter 1	Z-meter II	Z-meter 2A	Z-meter III	Z-meter IV
Impedance range	10 Ω – 10 MΩ	10 Ω – 1 MΩ	10 Ω – 1 MΩ	100 Ω – 1 MΩ	10 Ω – 1 MΩ
Frequency range	10 Hz – 8 MHz	100 Hz – 20 kHz	100 Hz – 10 kHz	1 kHz – 100 kHz	10 Hz – 200 kHz
voltage	0.01 V – 0.70 V step 0.005 V	0.5 V – 5.0 V, step 0.5 V	0.5 V – 5.0 V, step 0.5 V	1.0 V	0.2 V – 1.0 V
Module Z measuring accuracy	±0,2% from range	±2% from range	±2% from range	±2% from range	±2% from range
Phase accuracy	±0.2°	±2°	±2°	±2°	±2
Communication interface	RS 232	USB	USB, LAN, SC card	USB, SD card	USB, SD card, Ethernet, bluetooth
Number of measuring points	32	128	128	1, 8, 16, 32, 64, 128	1, 8, 16, 32, 64, 128, 256
Switch	external	internal	internal	internal, external	internal, external
Power supply	net	net battery	battery	battery	net battery

FINANCIAL DEMANDS OF THE SYSTEM

- Probe price approx. 125 Euro / 1 running meter without thermometers (in case of temperature measurement the price will increase by approx. 50%).
- GSM transmission 200 Euro.
- Active probe (signal transmission distances greater than 25 m) 700 Euro.
- The price includes operator training at LoWMR IoWS FCE BUT, CZ.
- The price of data processing software is solved separately according to the difficulty.
- Possibility of individual lease.

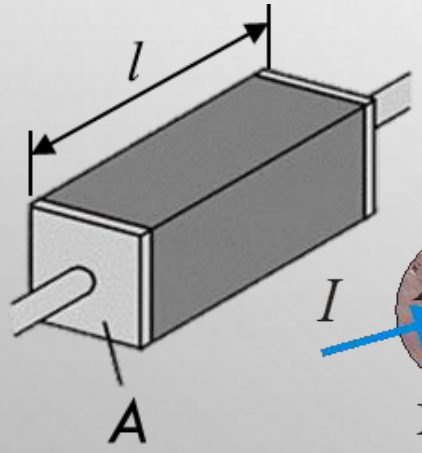
ths. € No. of channels	partner price	customer price
256	7.5	15.5
128	6.0	13.5
64	5.5	12.0
32	4.5	10.0
16	3.0	8.0
8	2.5	5.0
1	2.0	3.0

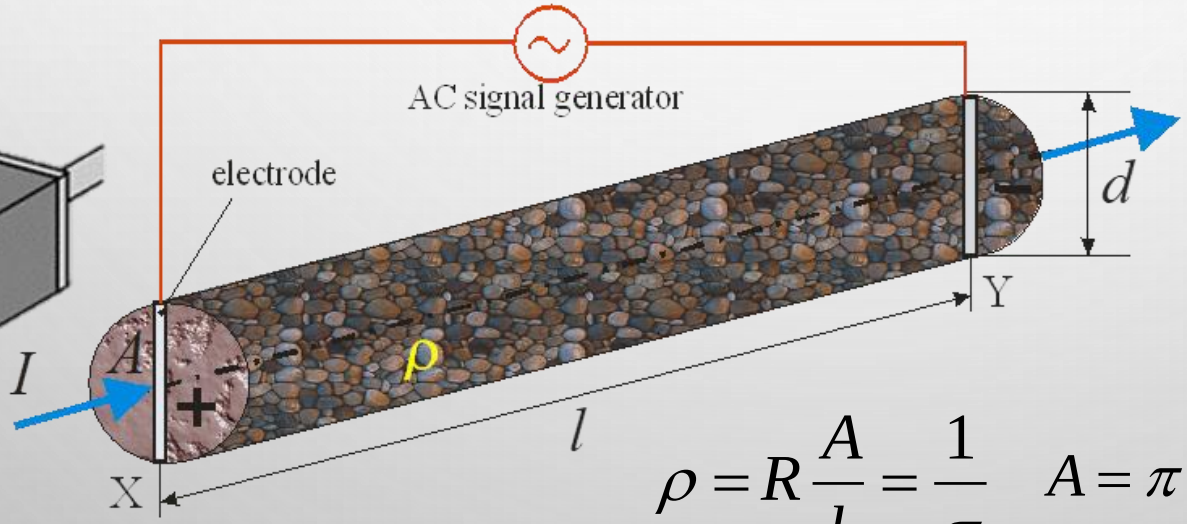


EIS – ELECTRICAL IMPEDANCE SPECTROMETRY

- The basic principle of the EIS method is to measure the frequency characteristics of the monitored substances - soil, wood, meat, bio-waste, building materials, etc. Non-zero moisture or ionic substance acts as an electric conductor, dry or frozen as an insulator.

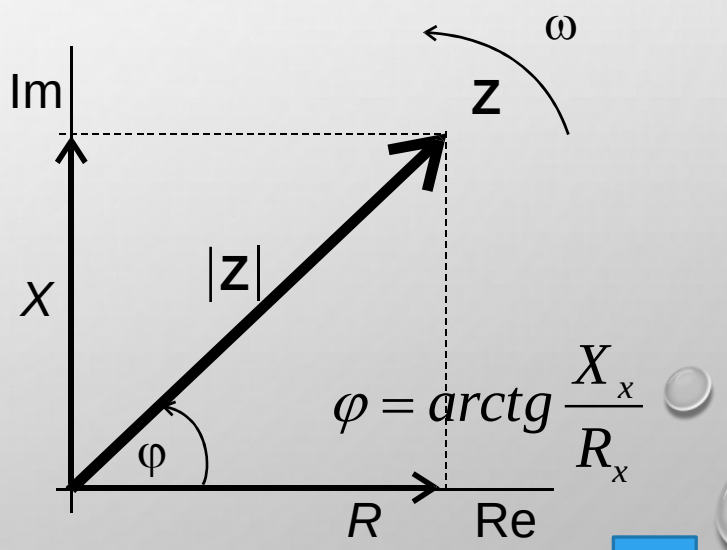
$$\mathbf{Z}(\omega) = R + j\,\omega\,X$$





$$\rho = R\frac{A}{l} = \frac{1}{\sigma} \qquad A = \pi\frac{d^2}{4}$$

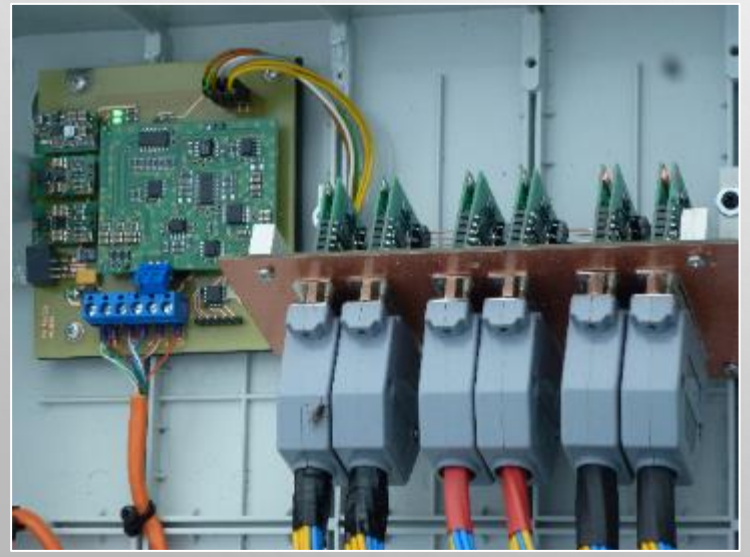
$$\omega = 2\pi f$$

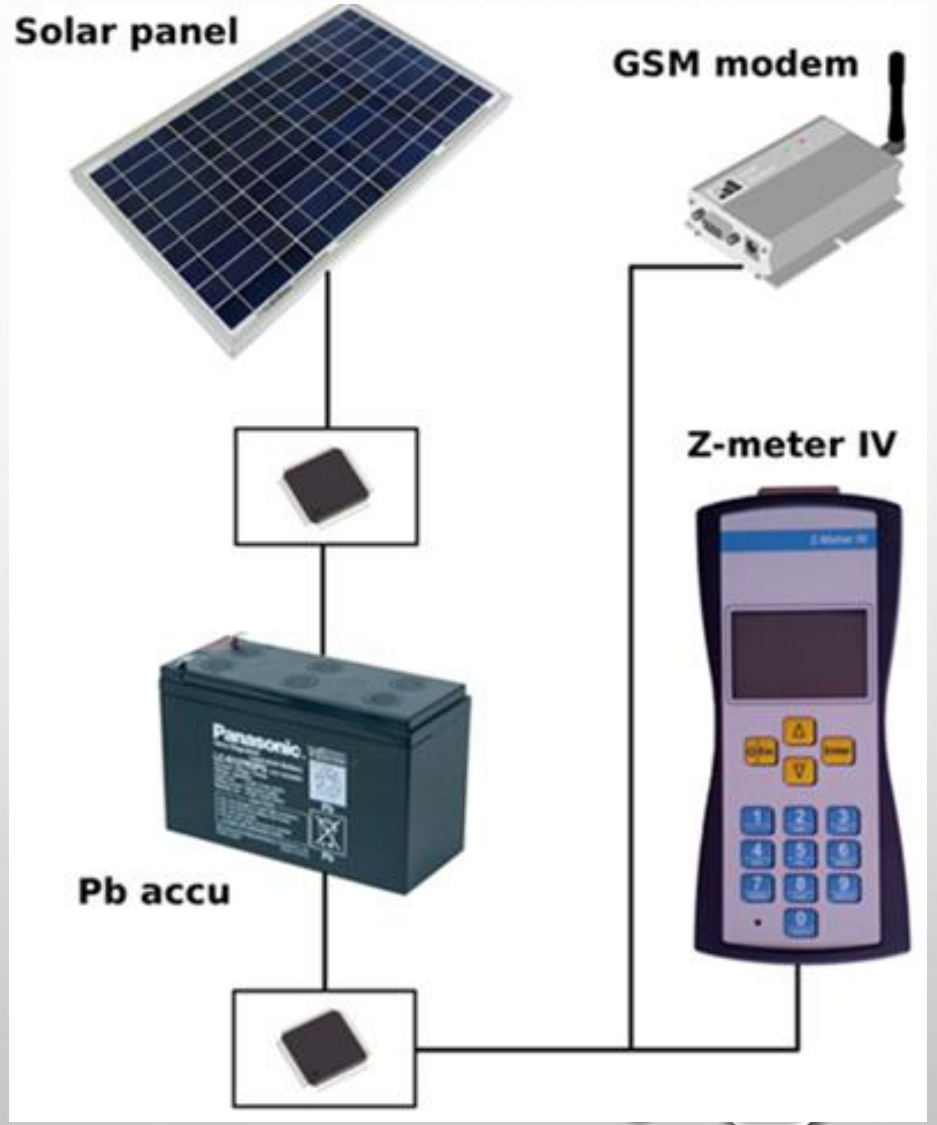


$$\varphi = arctg\frac{X_x}{R_x}$$

electric conductor ➡ low – dry, frozen substance,
good – with water, ions and etc. content

Full automatically measurement: composting process, BioSealing process at the dike, soil moister changes in different type of the forests.



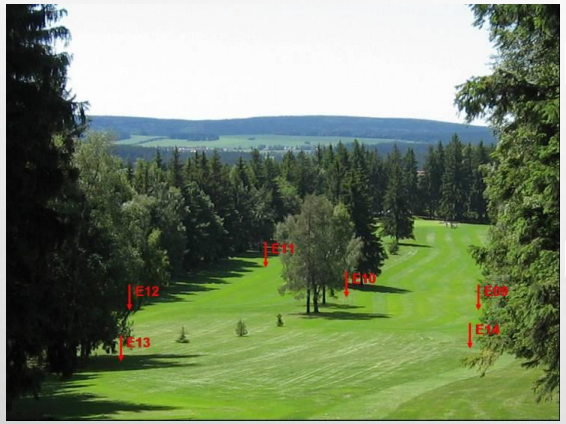


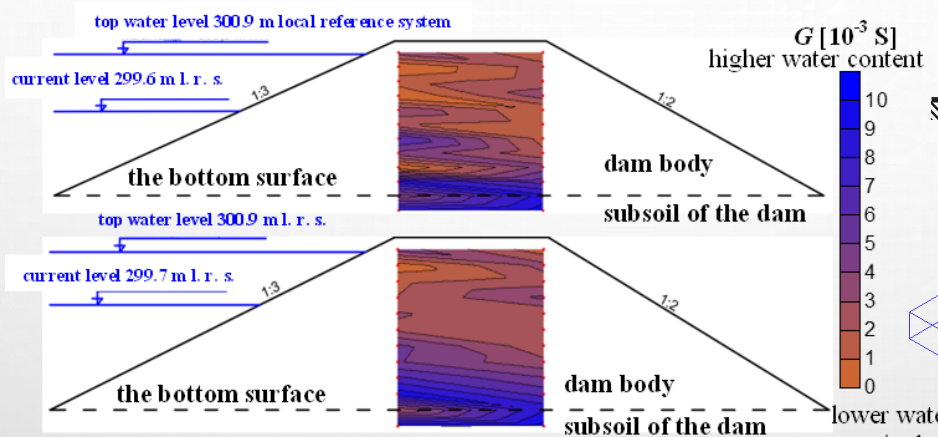
PROBES

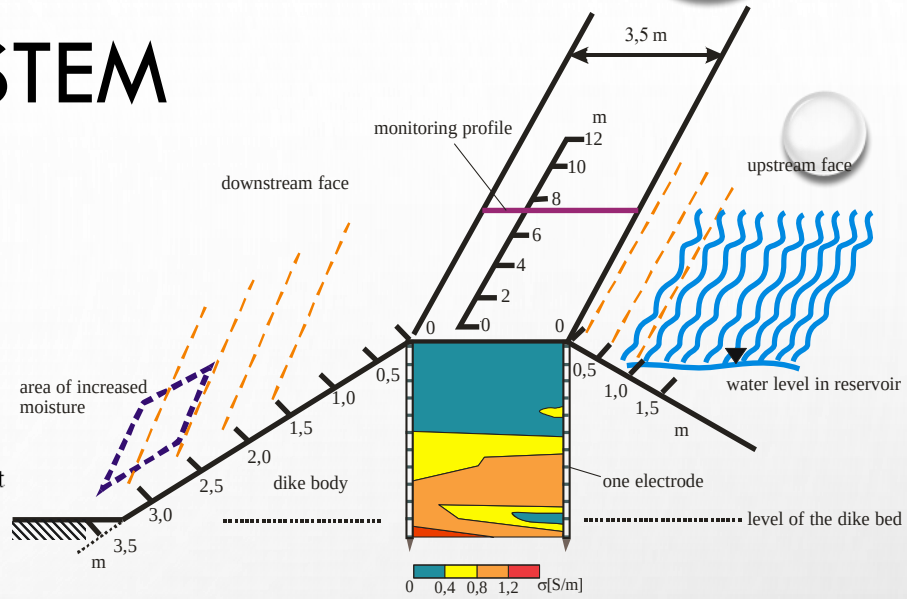
LABORATORY; TERRAIN.

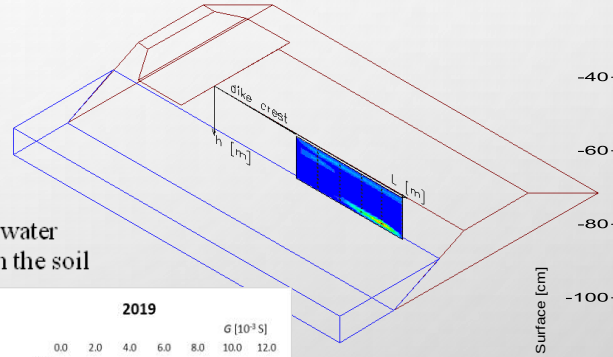
THE OUTPUTS FROM SYSTEM

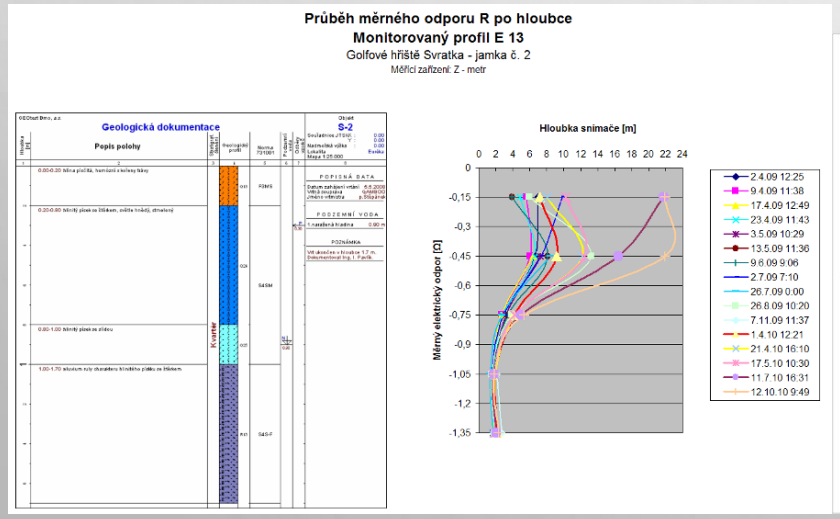
- Form of evaluation
  - tables (like MS excel), graphs, tomograms,
  - profiles (vertical, horizontal).
- Decision-making forms for process control.

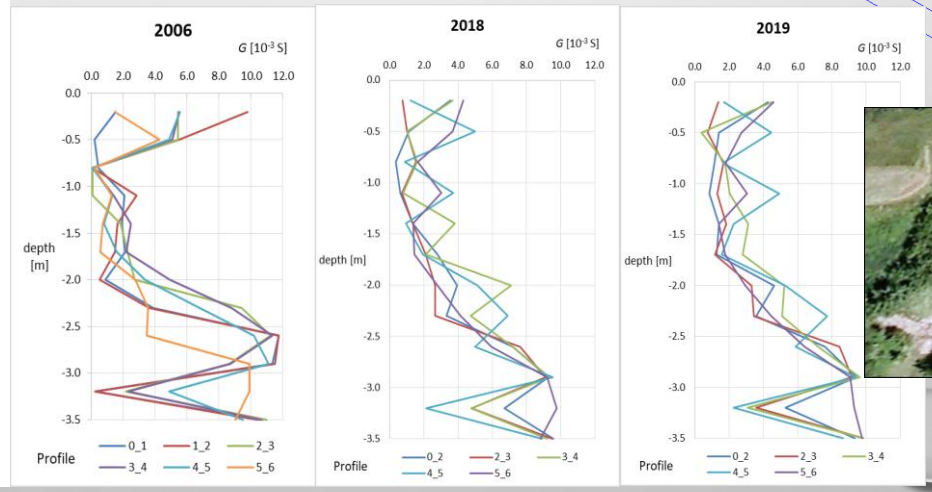


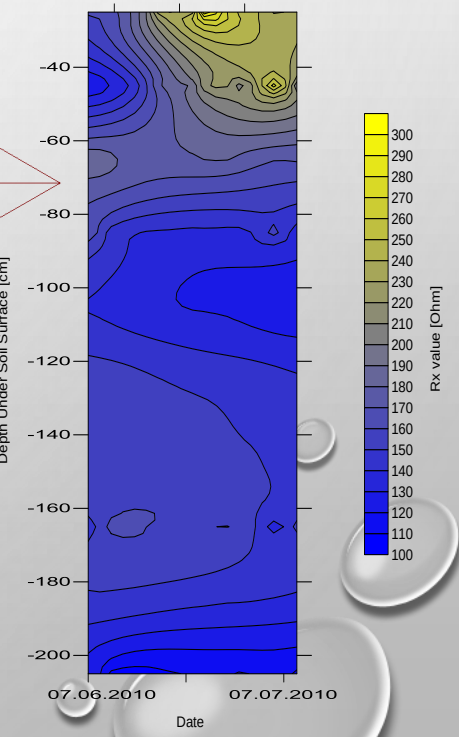








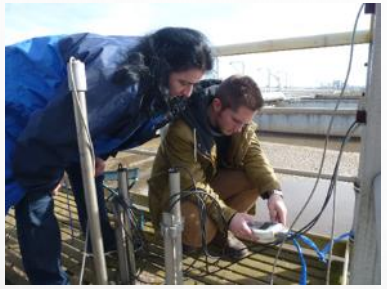




FIELD ACTIVITIES CARRIED OUT IN THE CZECH REPUBLIC

- MONITORING **IN FOREST** (SPECIES COMPOSITION OF TREES) - SCHOOL FOREST ENTERPRISE KŘTINY, MENDELU (KANICE, ÚTĚCHOV).
- MONITORING **IN SOUR CHERRY ORCHARD** (DIFFERENT GRASSLAND, ROOT LENGTH) - SCHOOL AGRICULTURE COMPANY ŽABČICE, MENDELU (ŽABČICE).
- MONITORING THE IRRIGATION AND FERTILIZATION PROCESS – **GOLF COURSES** (SVRATKA, KUNĚTICKÁ HORA).
- MONITORING OF THE **COMPOSTING PROCESS** - ZERA - AGRICULTURAL AND ENVIRONMENTAL REGIONAL AGENCY, Z.S. (COMPOSTING PLANT VÍCENICE NEAR NÁMĚŠŤ NAD OSLAVOU).
- MONITORING OF **EARTH DAMS** – LESNÍ SPRÁVA BUČOVICE, ČESKÝ RYBÁŘSKÝ SVAZ, MO JEVÍČKO, POVODÍ MORAVY, S. P., POVODÍ LABE, S. P. (KOBEŘICE, JEVÍČKO, KAROLINKA, HORNICE – **BIOSEALING PROCESS**, OPATOVICKÝ KANÁL) AND OF **RESERVOIR BOTTOM MORPHOLOGY** (KOBEŘICE, RÝZMBURK).
- MONITORING OF **THERMO REMEDIATION PROCESS** AND **WOOD BURNING** – THERMO SANACE, S.R.O. (CASTLE RYCHVALD, TIMBERED HOUSE ŠTRAMBERK, CHURCH BRNO (SK - BRATISLAVA, SPIŠSKÁ KAPITULA) WATER MILLS DOLNÍ NĚMČÍ AND WESSELSKY LOUČKY NAD ODROU).
- MONITORING OF **SNOW STRATIFICATION** (CZ, AUSTRIA, FINLAND).
- MONITORING OF **MASONRY MOISTURE** (CASTLE RYCHVALD).
- MONITORING OF **AERATION PROCESS** AT THE WASTEWATER TREATMENT PLAT (MODŘICE, BRNO WATERWORKS AND SEWERAGE).
- MONITORING OF **BEEF RIPENING**.

ERASMUS+ AND EUREKA STUDENT WORK IN CZECH REPUBLIC













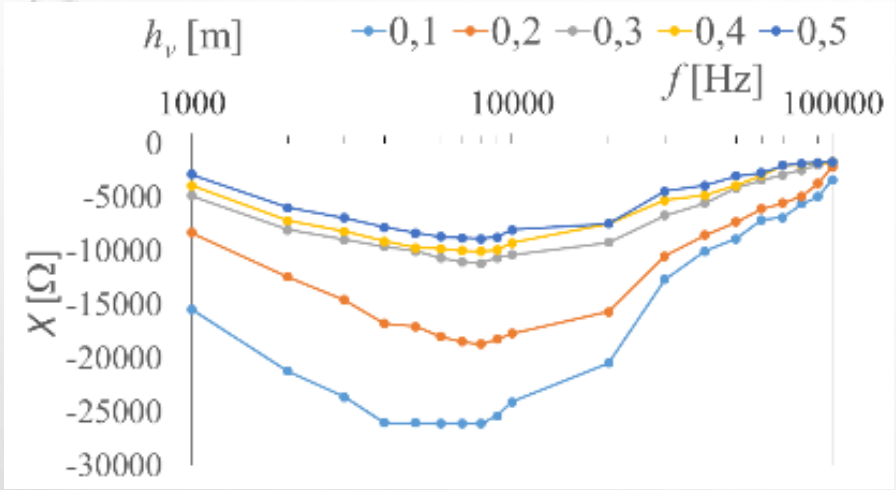


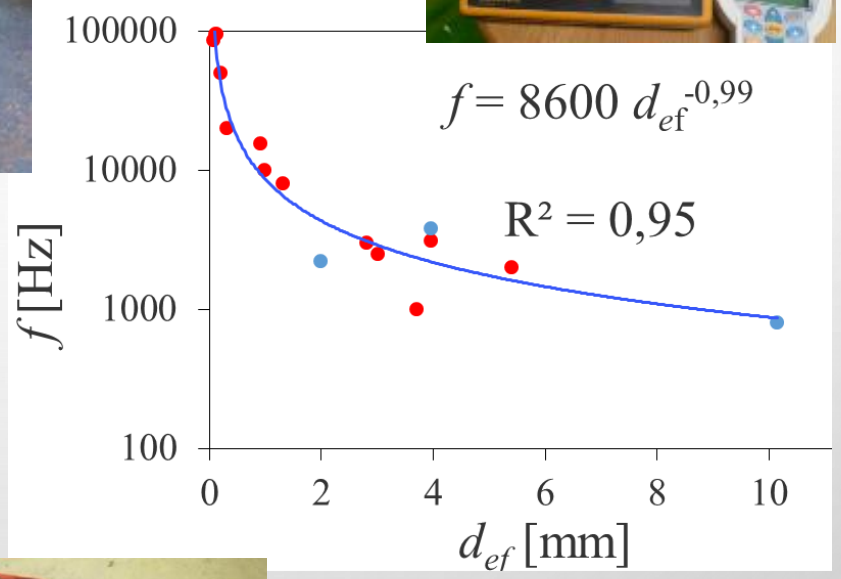




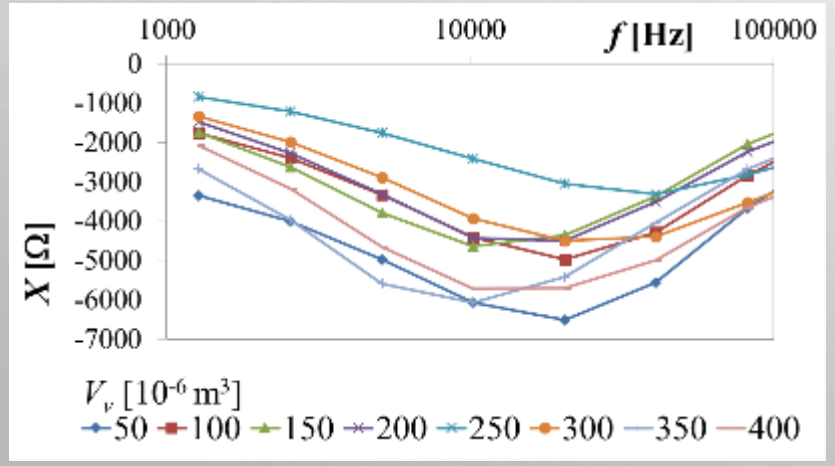
DEPENDENCE OF THE FREQUENCY OF THE MEASURING SIGNAL ON THE SIZE OF THE EFFECTIVE SOIL GRAIN

Frequency analysis of a sample of "Bratčice sand" by d_{ef} = 1.3 mm





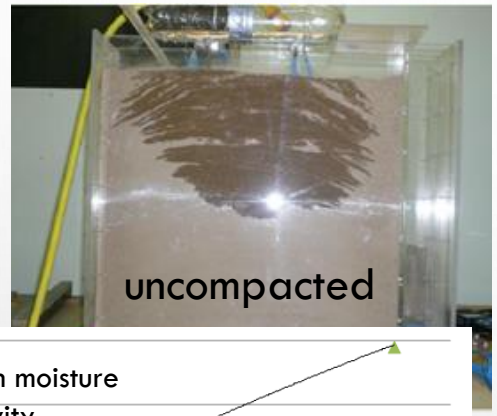
Frequency analysis of a sample of "Oostende sand" by d_{ef} = 0.3 mm



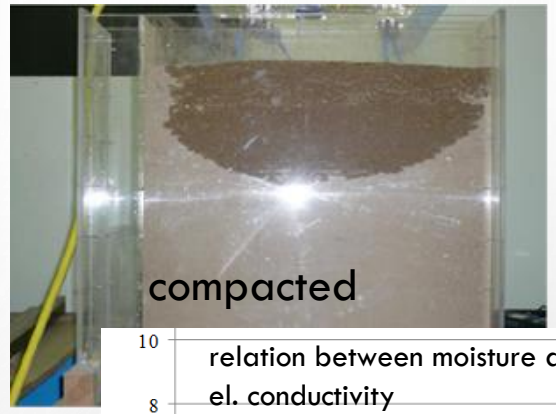
Soil	f_M [Hz]	d_{ef} [mm]
Sand Westerschelde	86000	0.063
Glass sphere	98500	0.100
Marine sand	96000	0.125
Marine sand	96800	0.110
Sand Mol	96000	0.100
Glass sphere	15800	0.200
Sand Schelde	50000	0.200
Sand Schelde	45600	0.200
Sand Oostende	20000	0.300
sand Bzenec	19000	0.550
Glass sphere	19200	0.500
sand Kunštát	2800	0.870
kora_modified	15600	0.900
Garden loam	10000	0.980
Garden loam	9850	1.280
Bratcice sand	8000	1.300
Glass sphere	4000	2.100
Glass sphere	2200	2.000
Silica sand full curve	3000	2.800
Rubble	2500	3.000
sandy loam	2220	3.400
Silica sand modif	1000	3.700
Glass sphere	3800	3.960
Bratcice sand	3100	3.960
loamy soil	2880	4.200
Bratcice sand	2000	5.400
Glass sphere	1200	6.250
Bratcice sand	1250	6.300
Bratcice sand	980	8.200
Glass sphere	800	10.150

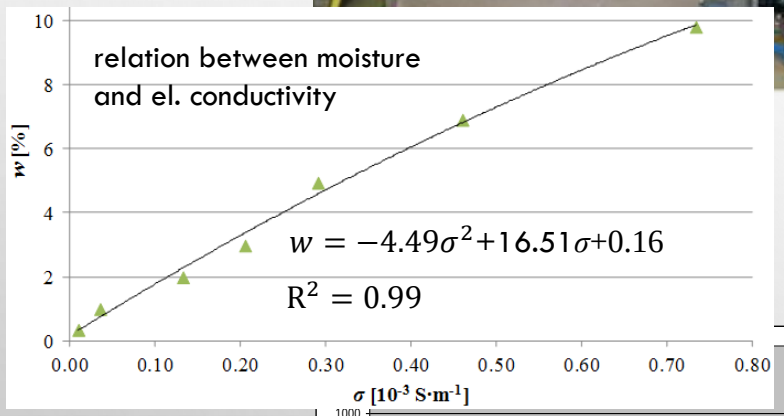
WATER INFILTRATION INTO THE SAND IN LAB

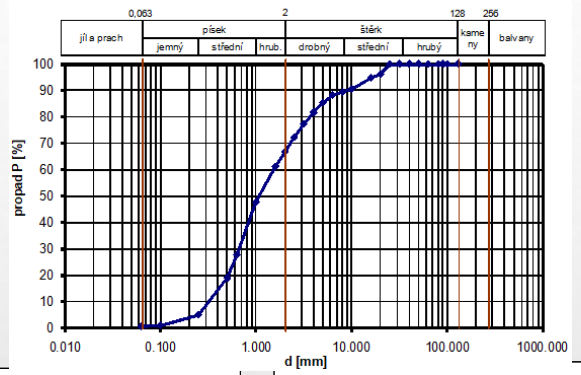
The sample of "Bratčice sand" by d_{ef} = 3.2 mm; loading with a rain intensity of approx. 2000 l·s^{-1}·ha^{-1}, which corresponds to a rainfall of approximately 12 mm·min^{-1} (rain intensity during a local flood).

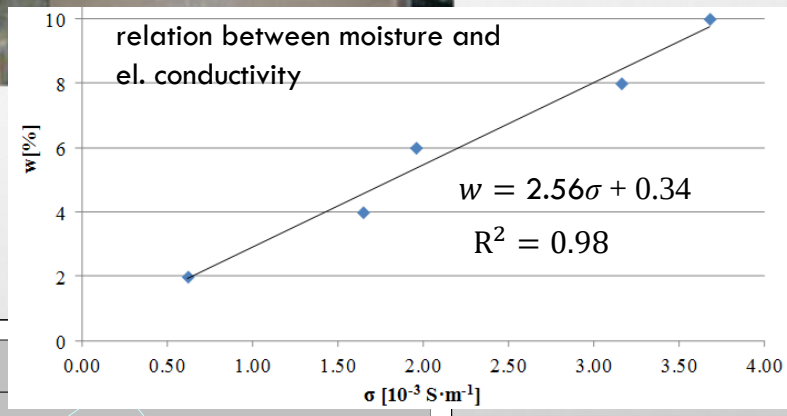


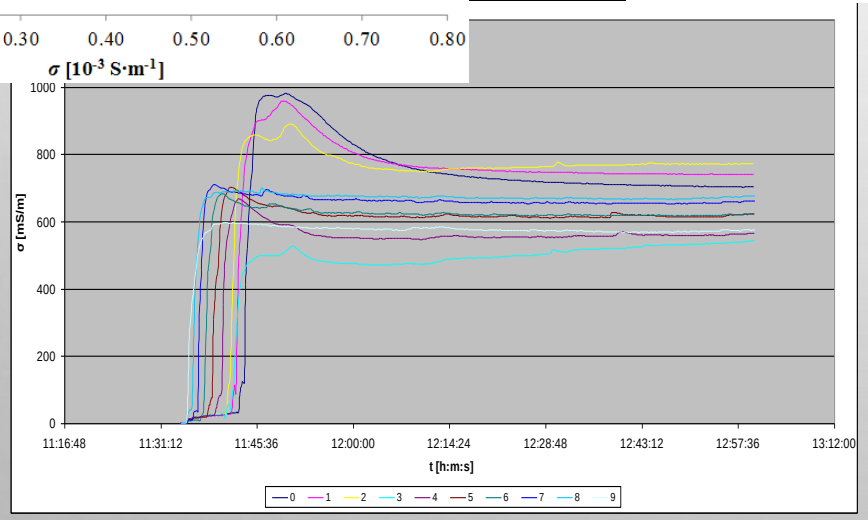
sample	Moisture [%]		Temperature [°C]	
	initial	final	initial	final
uncompacted	17.2	98.7	23.0	22.2
compacted	19.1	99.9	23.8	22.1

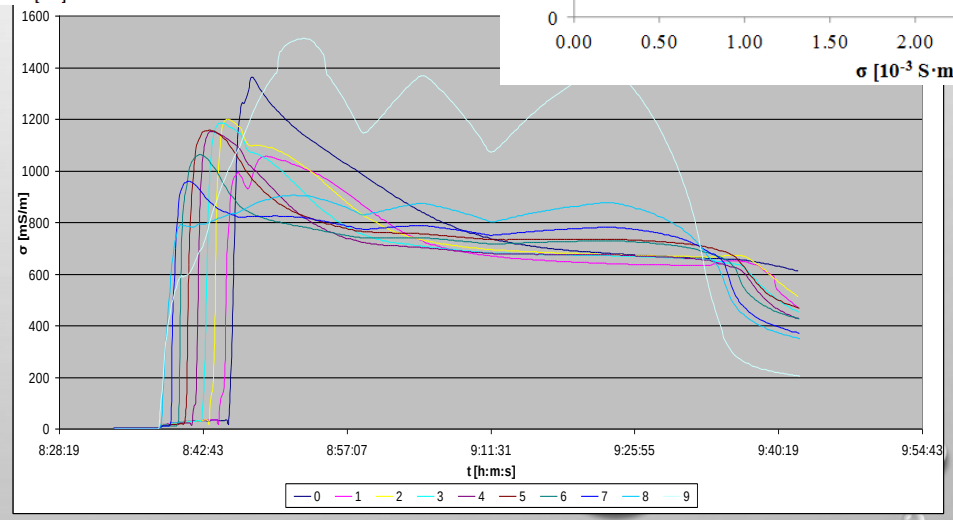










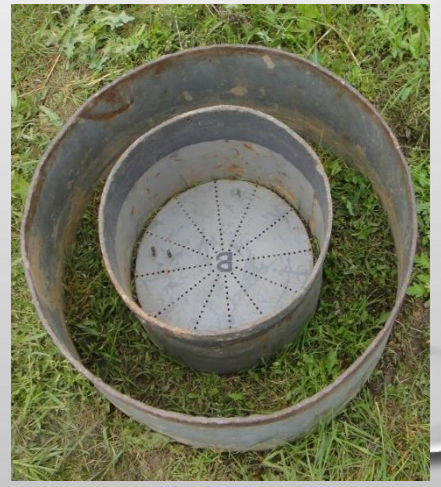


WATER INFILTRATION IN THE SOIL

- **INFLUENCING FACTORS;**
  - hydrological – intensity and duration of precipitation.
  - soil – granularity, organic matter content, porosity, structure and soil moisture.
- **MEASUREMENT OF THE PROCESS TOGETHER WITH PL AND SK PARTNERS;**
  - infiltrometer – cylindrical heating, compact overpressure, simple pressure.
  - rain simulator, Guelphs permeameter, SATURO.

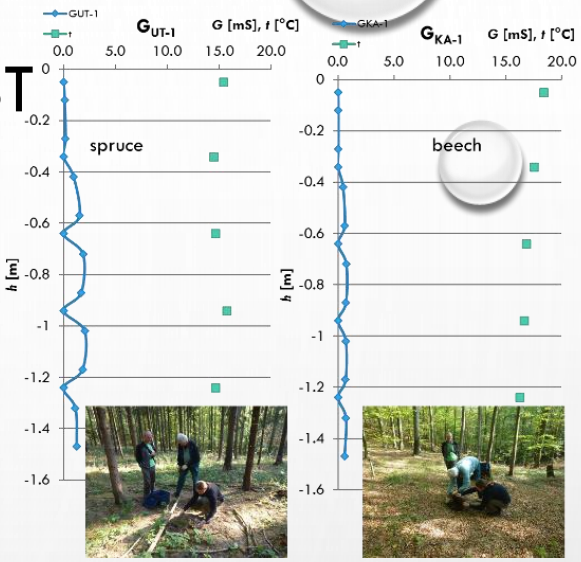


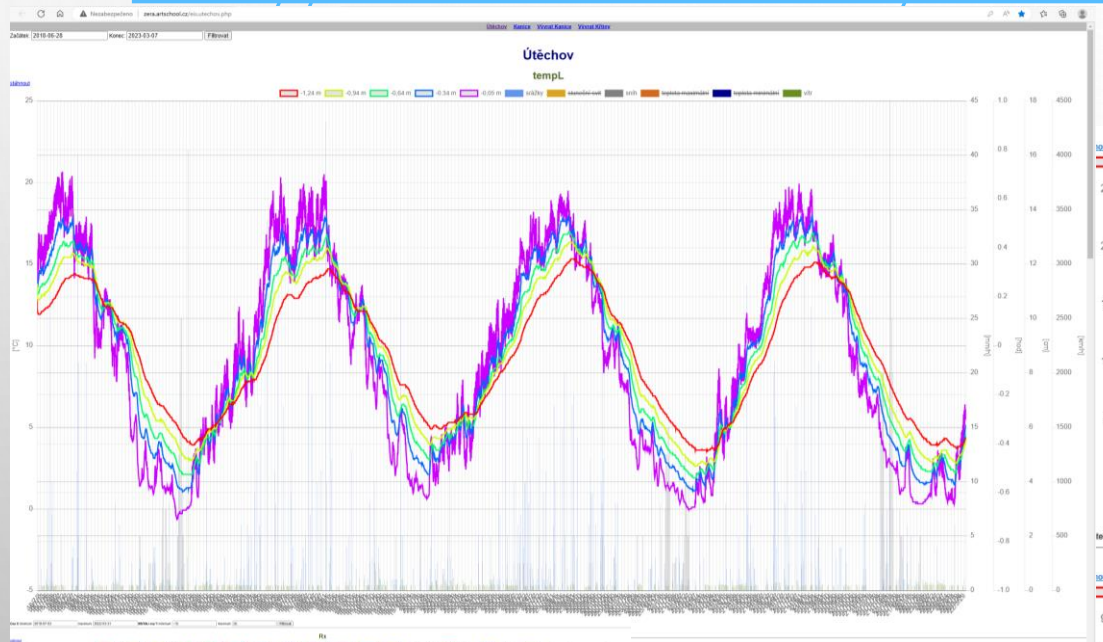


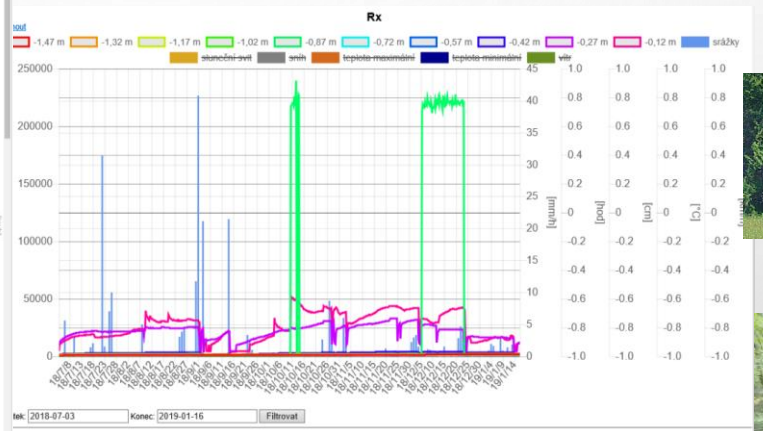



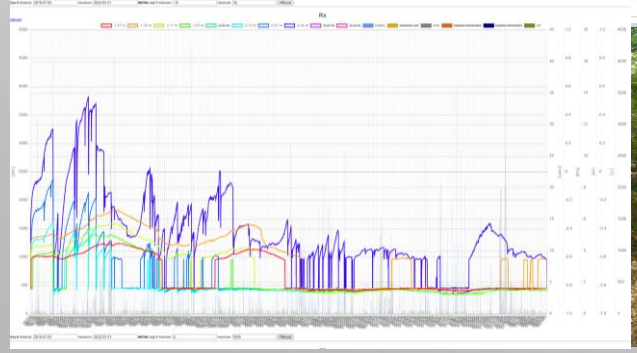
WATER INFILTRATION – SPECIES COMPOSITION OF THE FOREST OF THE SAME AGE

- School forest enterprise Křtiny, Mendel University in Brno (Kanice - beech, Útěchov - spruce).
- [HTTP://ZERA.ARTSCHOOL.CZ/EIS.UTECHOV.PHP](http://zera.artschool.cz/eis.utechov.php)



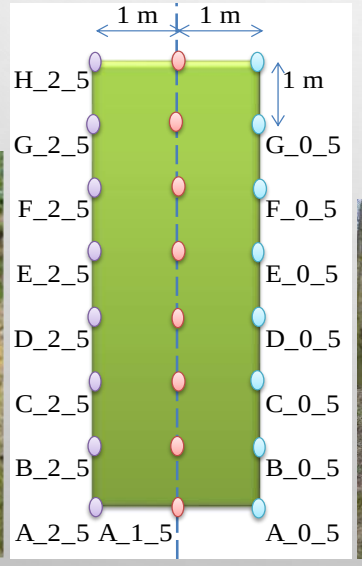


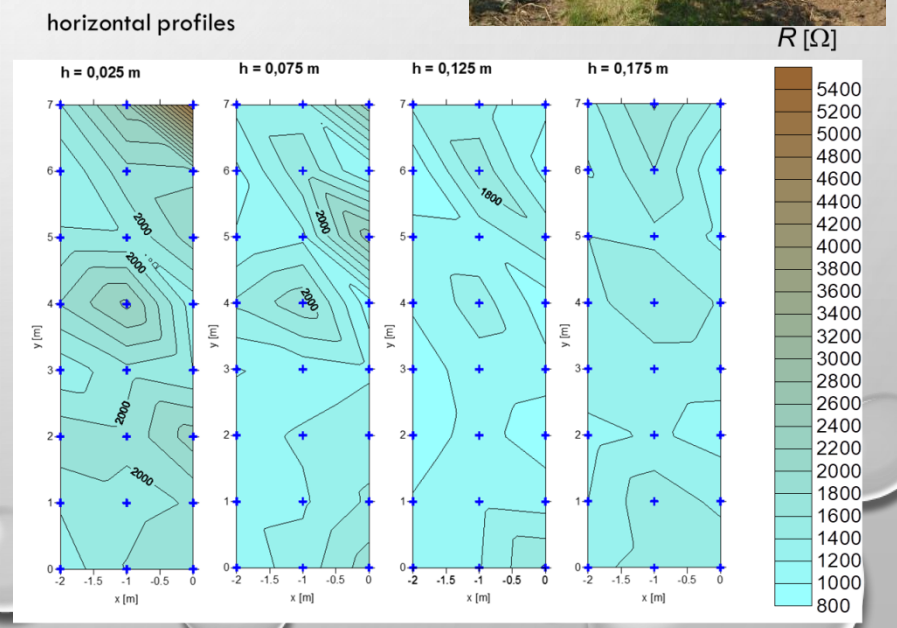




WATER INFILTRATION – SPECIES COMPOSITION OF THE GRASSES

- School Agriculture Company Žabčice, Mendel University in Brno (Žabčice – cherry orchard).
- Fescue grass (kostřava) length of roots to 2 m × weed × usual grass with length of roots to 0.3 m.
- Dry × irrigation (to 1 m^2 was poured about 10 l/s).
- Stable probe to 0.85 m (7 levels) and mobile probe (a pitchfork with two prongs) from 0.05 m to 0.20 m.
- Measurement 1× per month.

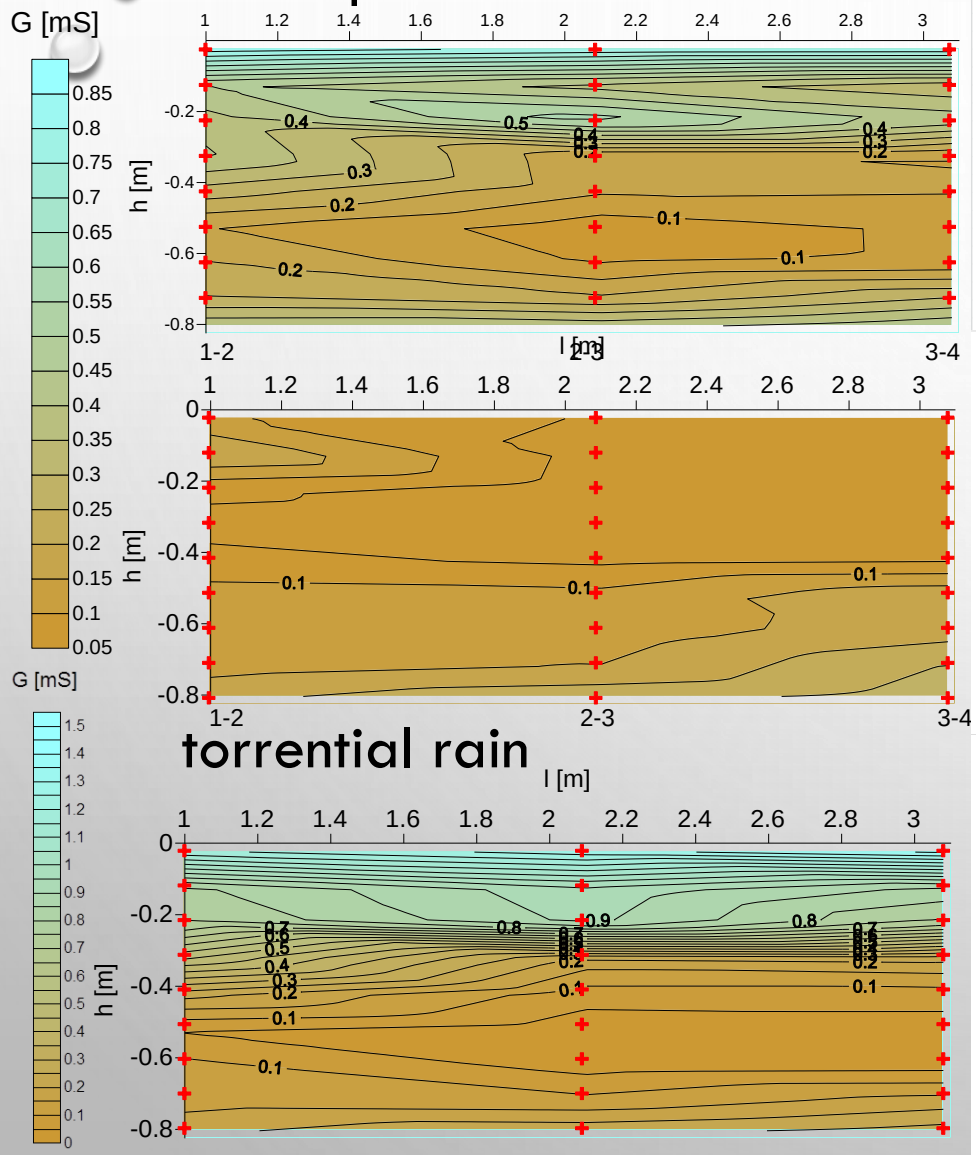


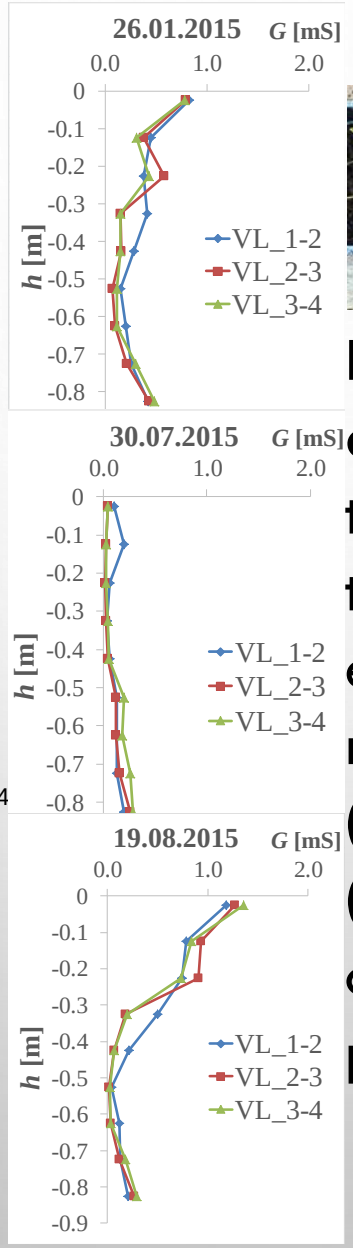


The higher the *R* value (brown color), the lower the water content of the soil.

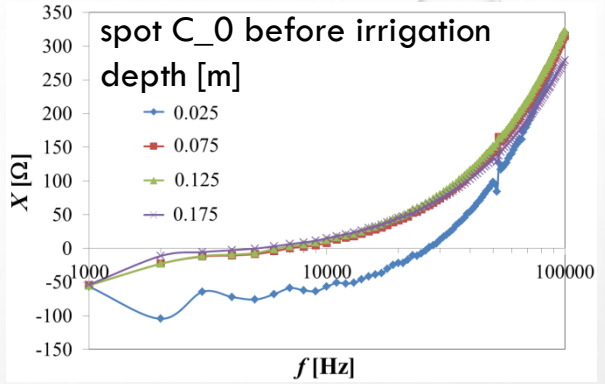
ELECTRICAL CONDUCTANCE MAPS, FREQUENCY ANALYSIS

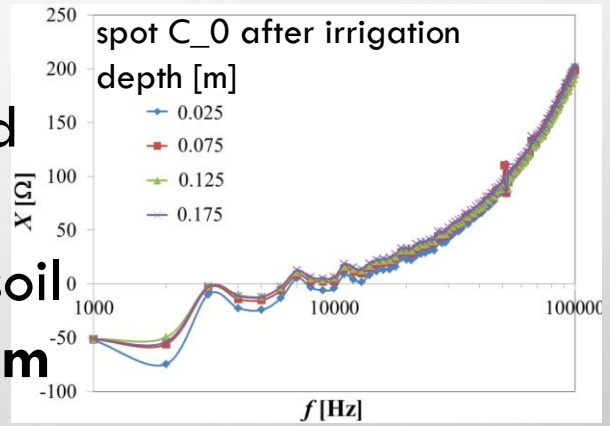
vertical profiles

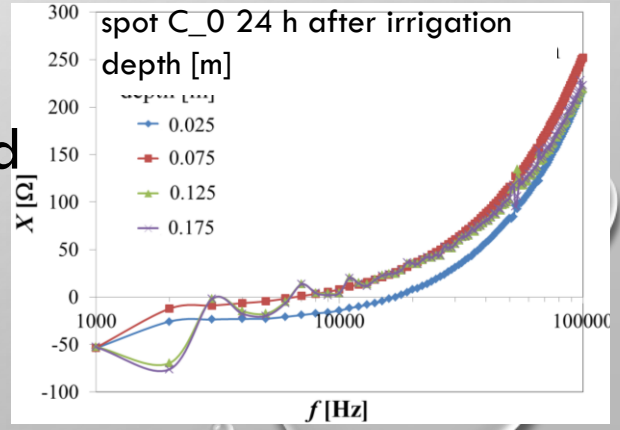




Based on experience and the results of lab. tests, it can be assumed that the size of the effective grain of the soil ranges between **0.9 mm (matrix)** and **3.9 mm (grain of the sand)** on the whole monitored profile.



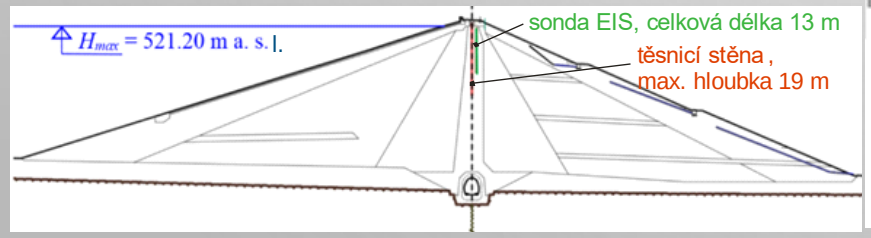


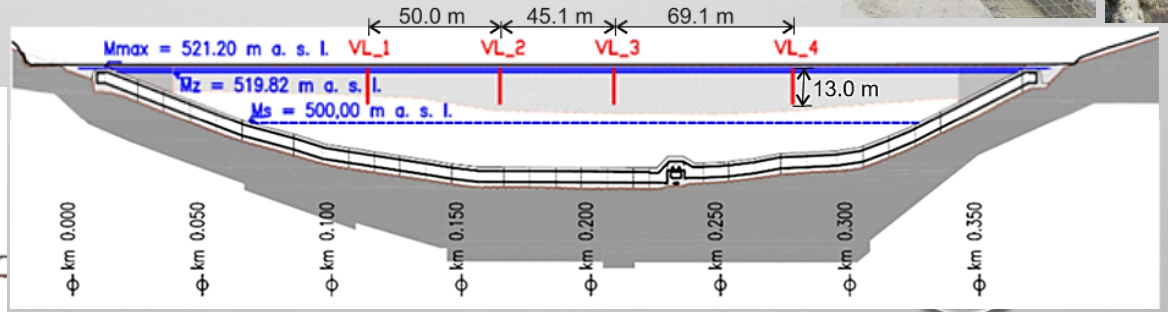


EARTH-FILL DAMS

- Cooperation with river basin enterprises, designers, forest management, private organizations.
- Monitoring of dams of small water reservoirs, protective and dam dams. Different probe length and connection.
- **WS Karolinka** – problem with soil quality and its storage, monitoring from March 2011 yet, 4×per year now, max. probe length 13 m, 20 measured levels, one tube with different sensors distance (max. 2 m), sensors are placed in problematic levels, reconstruction in 2013 – installation of a sealing wall, first probe was destroyed and had to be installed new.

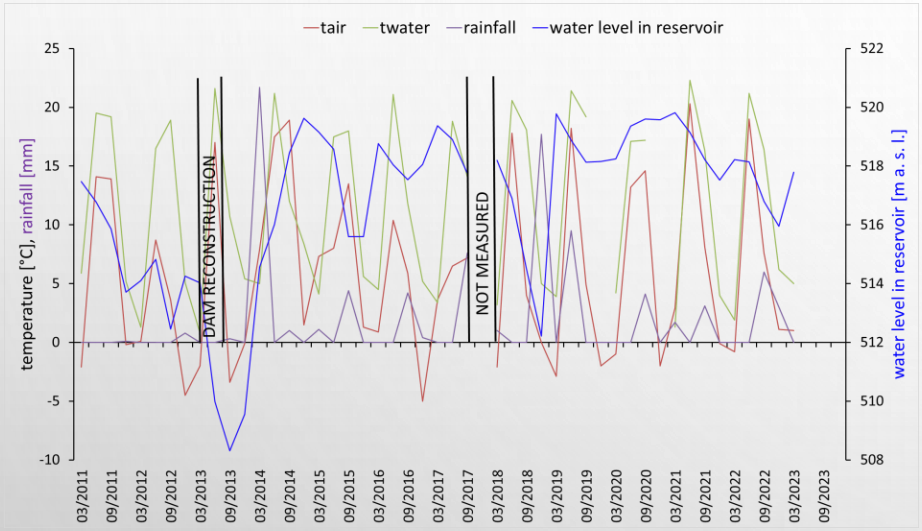
Nonhomogeneous material

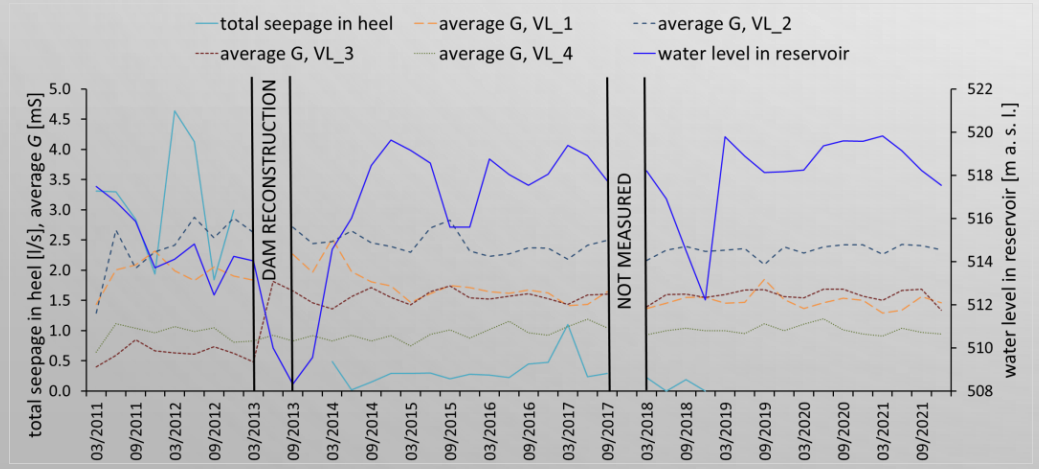


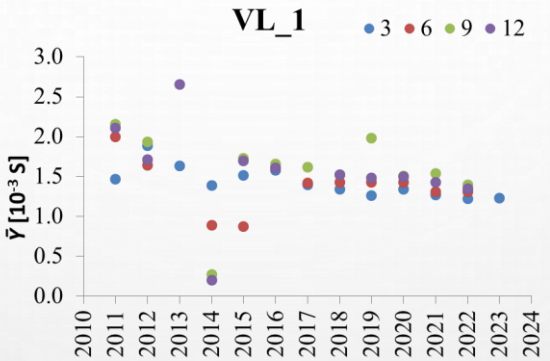


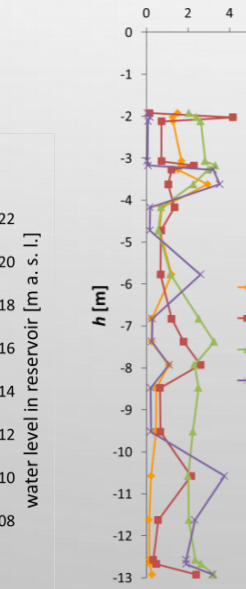
WATER STRUCTURE KAROLINKA – EIS RESULTS

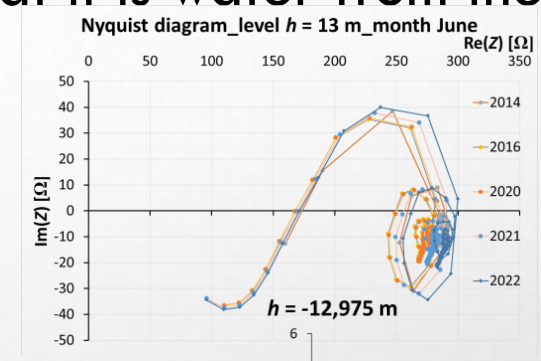
Installed sealing wall has reduced dike seepage, but (as it is not the same height everywhere) the problem remains between the probes VL_1 and VL_2. There is probably an increase in soil moisture when the wall underflows. It has not been proven that it is water from the reservoir.

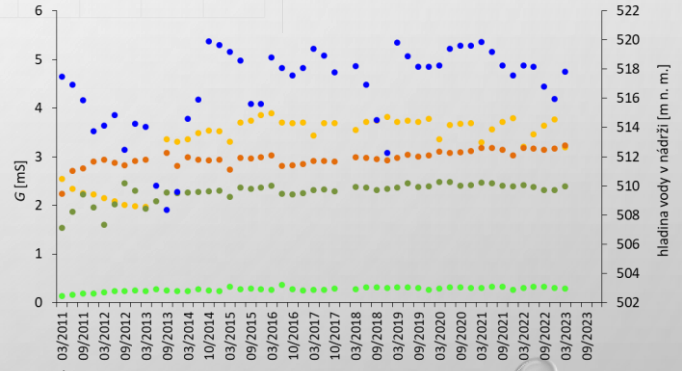


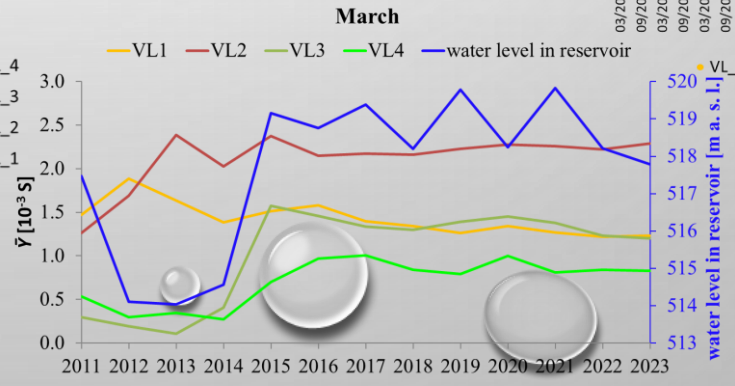


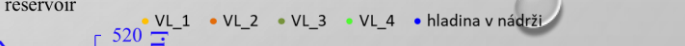






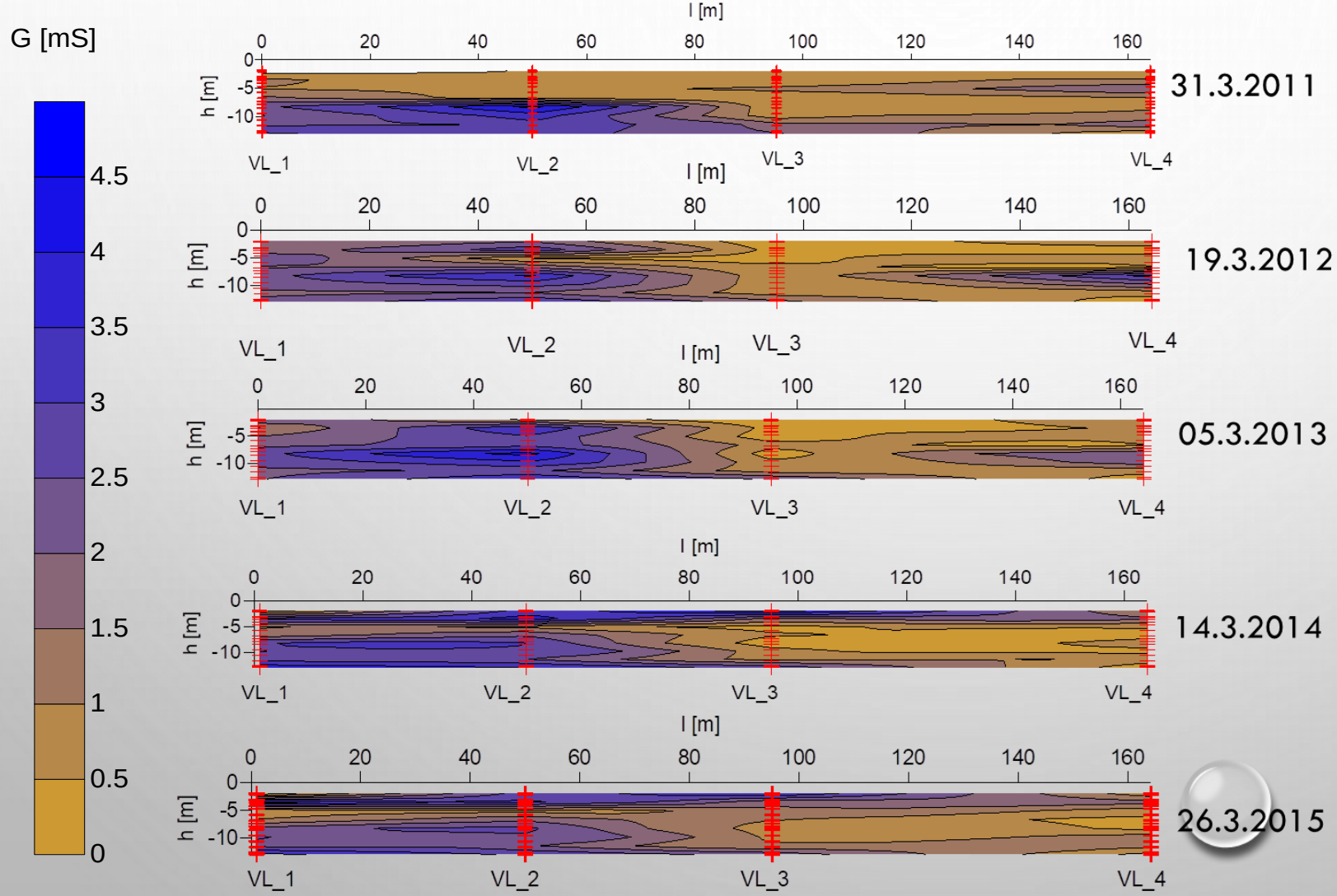




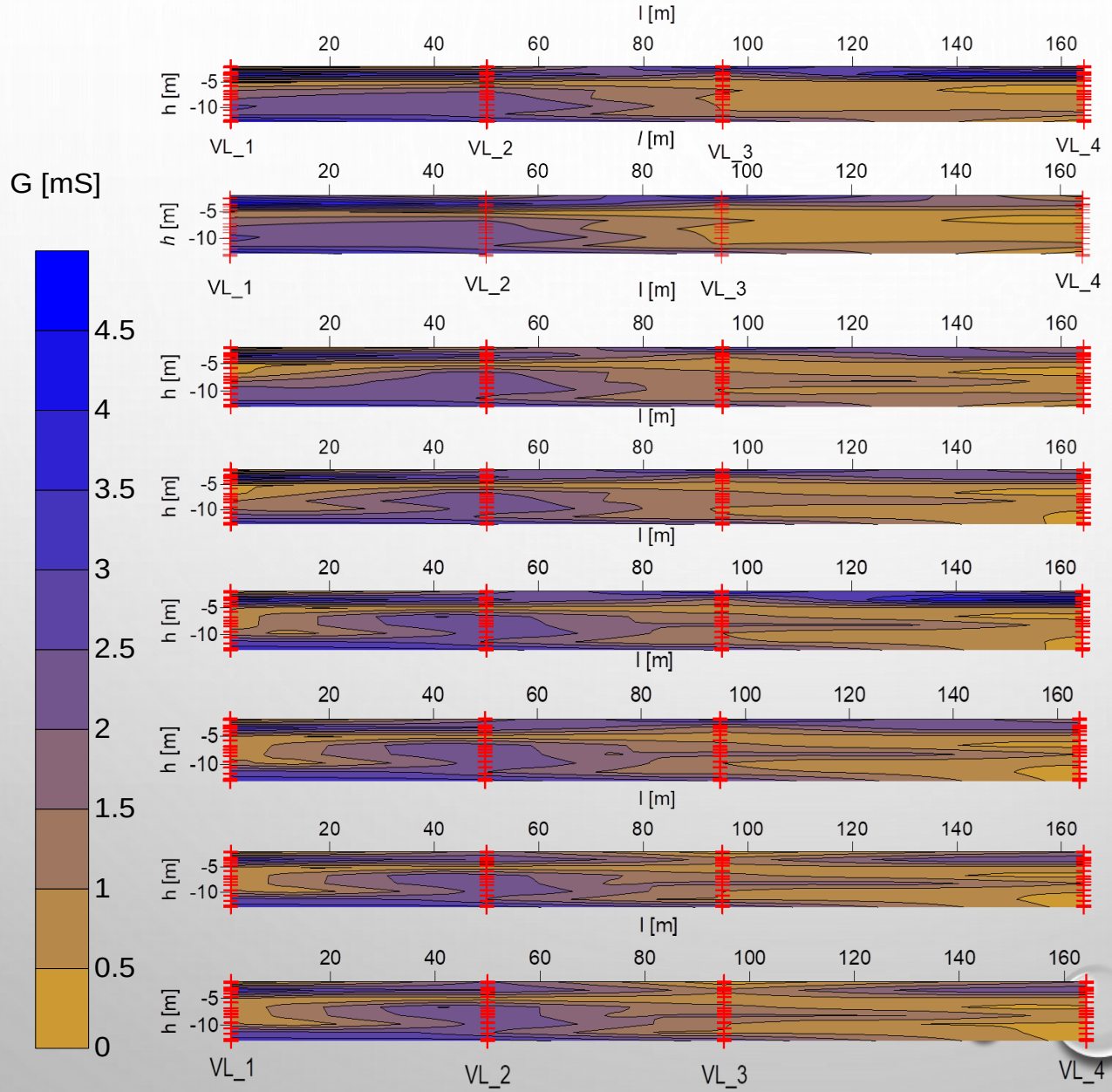


KAROLINKA – MARCH_EL. CONDUCTANCE MAPS

Consecutively are shown the maps of electrical conductance measured in March from 2011 to 2023. The colour scale of the electrical conductance is the same for all maps.



KAROLINKA – MARCH_EL. CONDUCTANCE MAPS



30.03.2016

23.03.2017

28.03.2018

21.03.2019

26.03.2020

24.03.2021

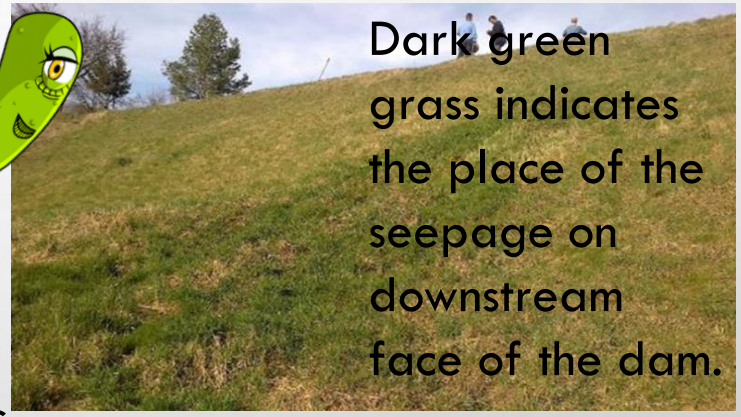
24.03.2022

30.03.2023

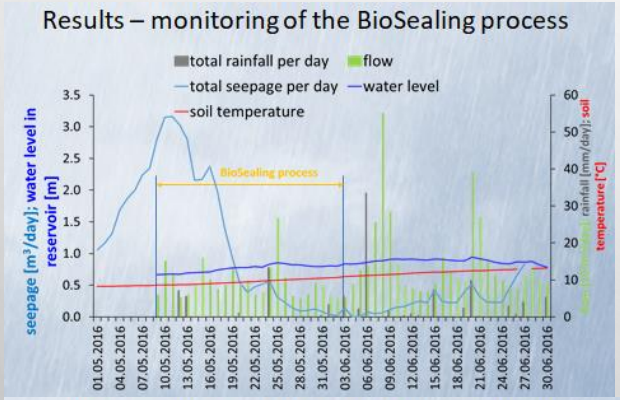
EARTH-FILL DAMS – BIOSEALING PROCESS

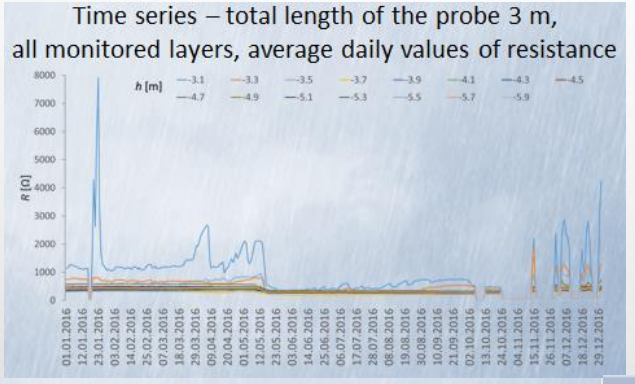
- Earth-fill dam hornice monitored by EIS method during application of nutrient aqueous solution used in BioSealing method.
- BioSealing is caused by a combination of microbiological and geochemical processes.

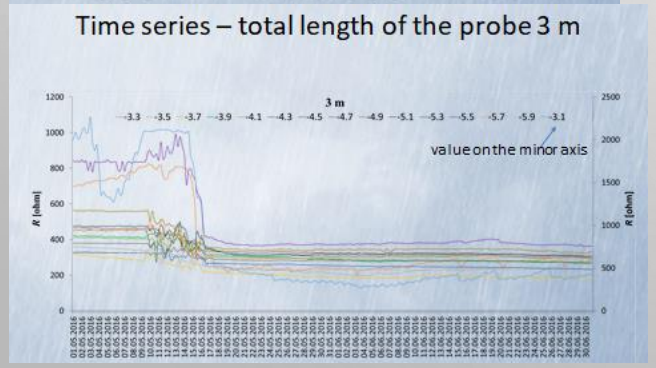
Converging groundwater flows transport the nutrients towards the leak, where bacteria would induce clogging and reduce the flow rate through the leaking structure.

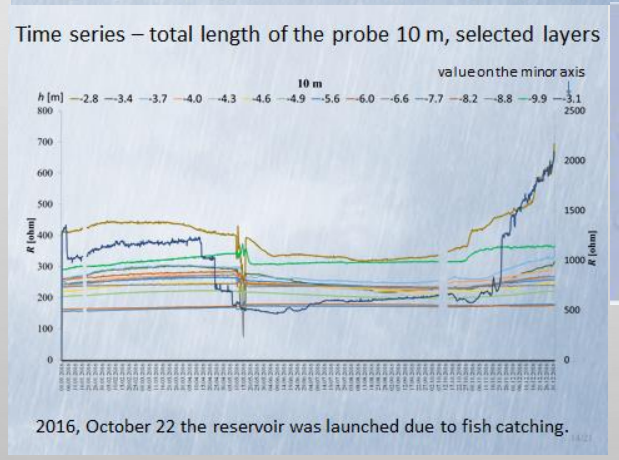


Dark green grass indicates the place of the seepage on downstream face of the dam.

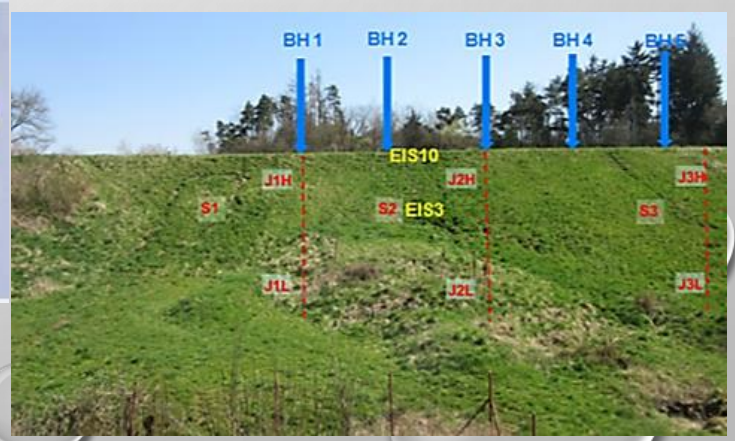




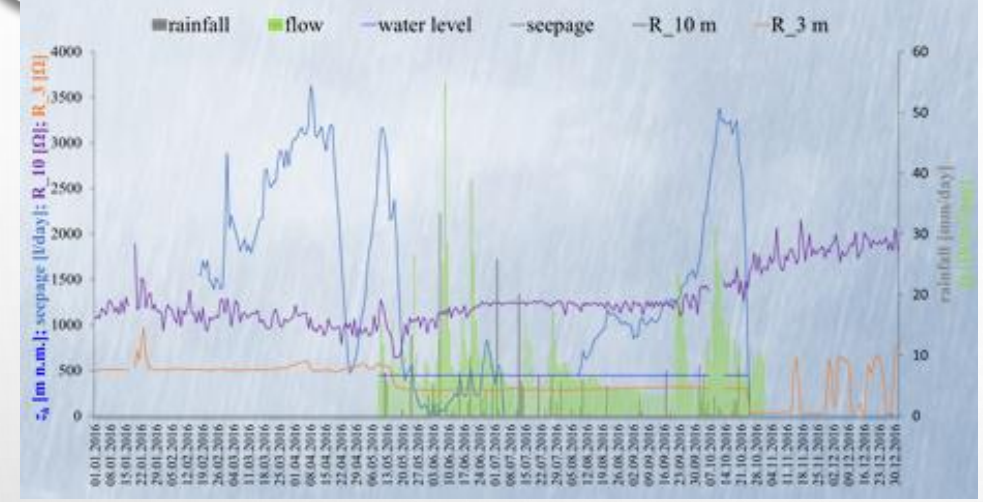




colonies of microorganisms in the soil



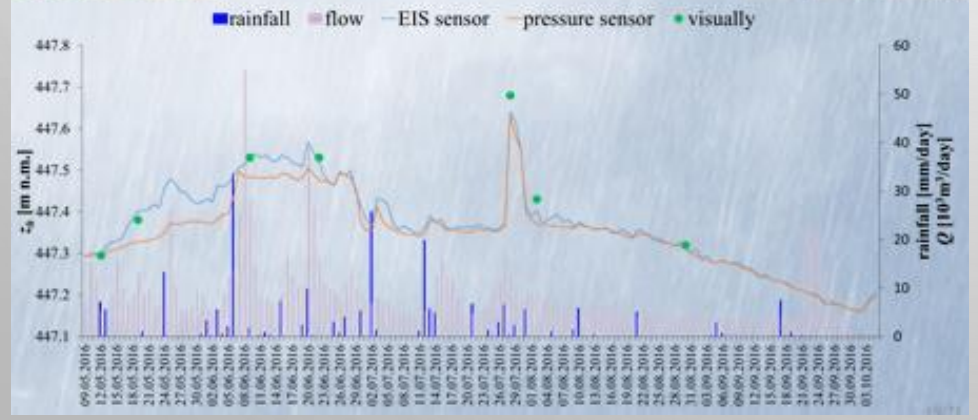
Average daily values of the monitored parameters



Monitoring of the water level in reservoir

Rainfall – Moravské Budějovice

Flow – Jemnice



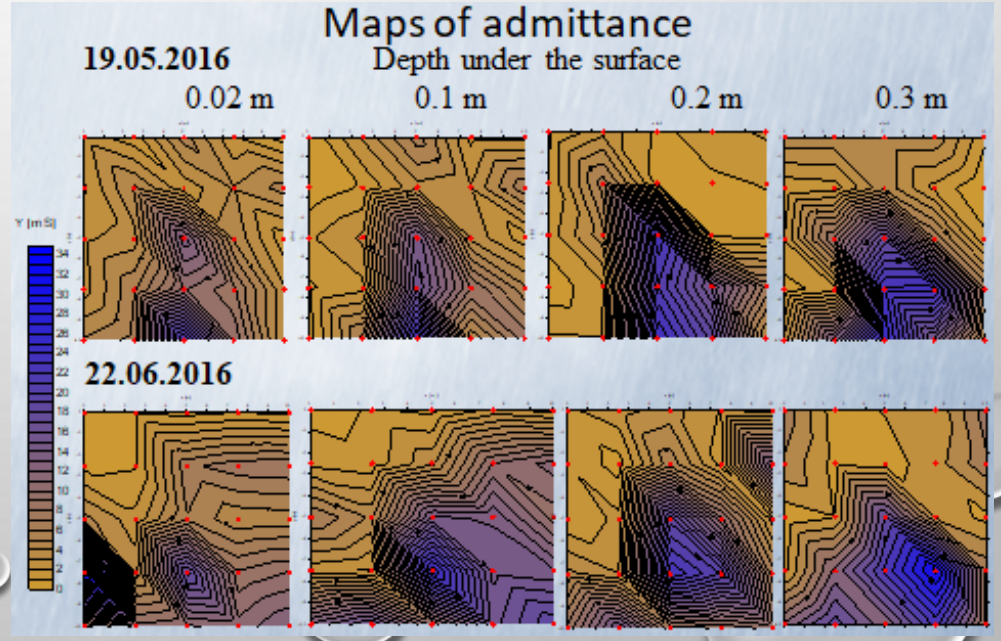
Maps of conductance to depth 0.3 m

Measurement on May and June 2016.

Measurement by the fork probe.

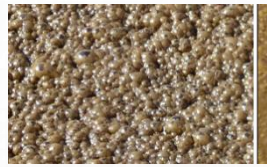
Surface layer – depth 0.02 m.

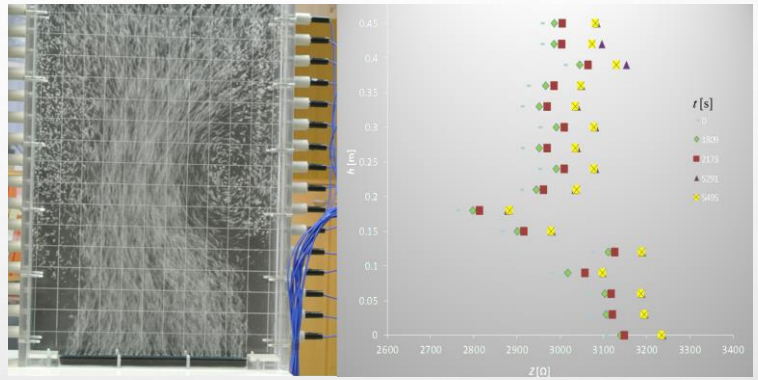
Maps of admittance

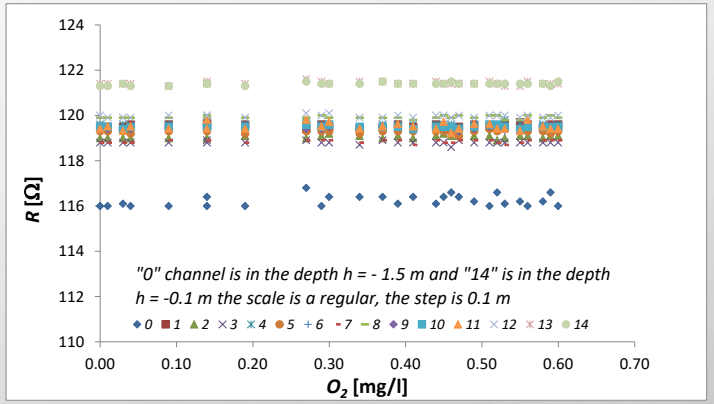


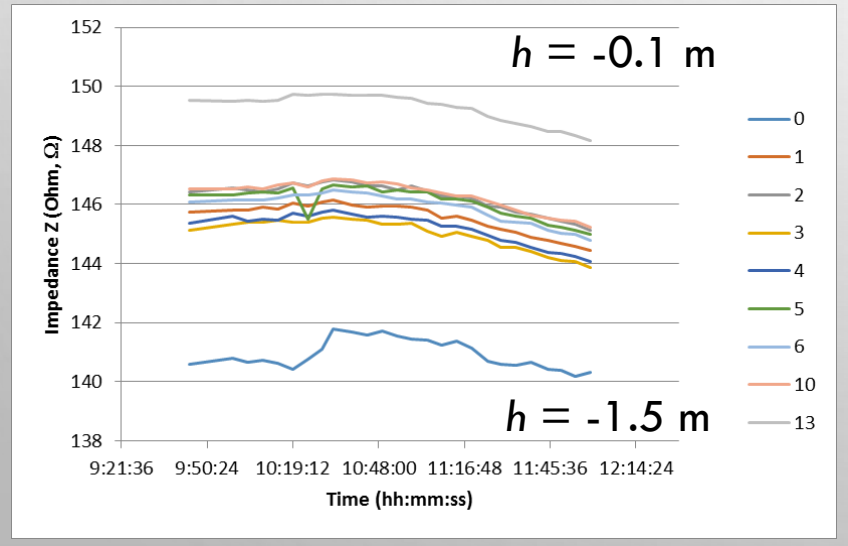
WASTE WATER TREATMENT PLANT MODŘICE - AERATION

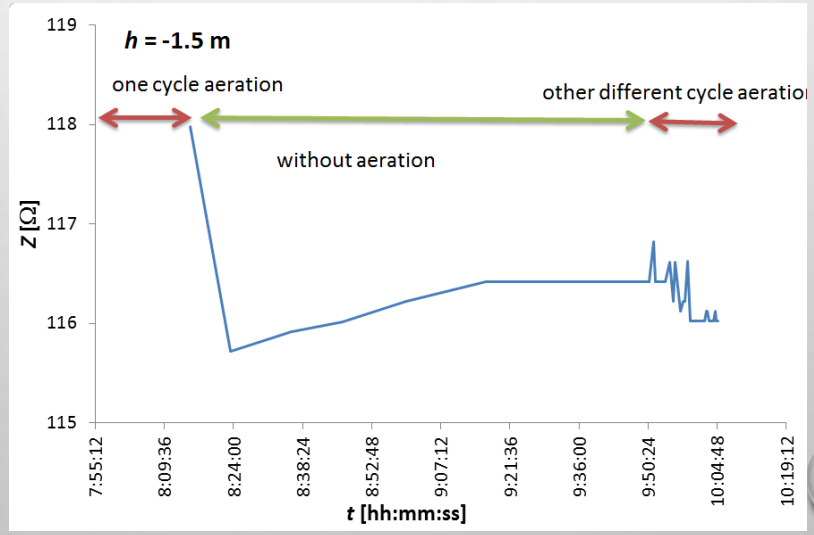
Disparity consistency of sludge during aeration.

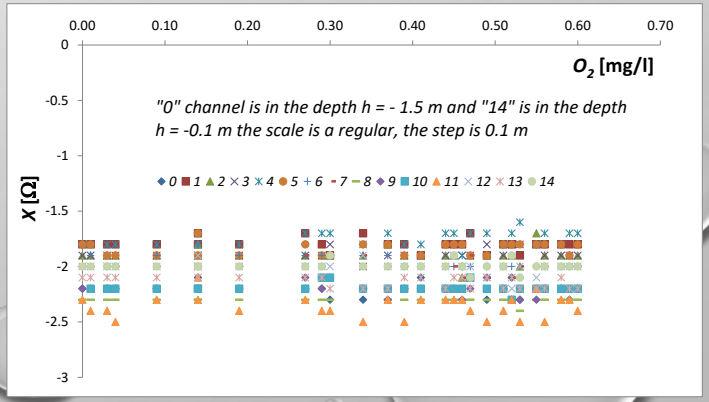




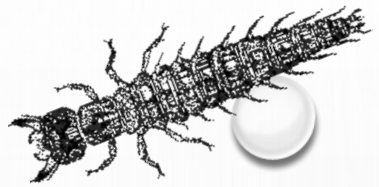




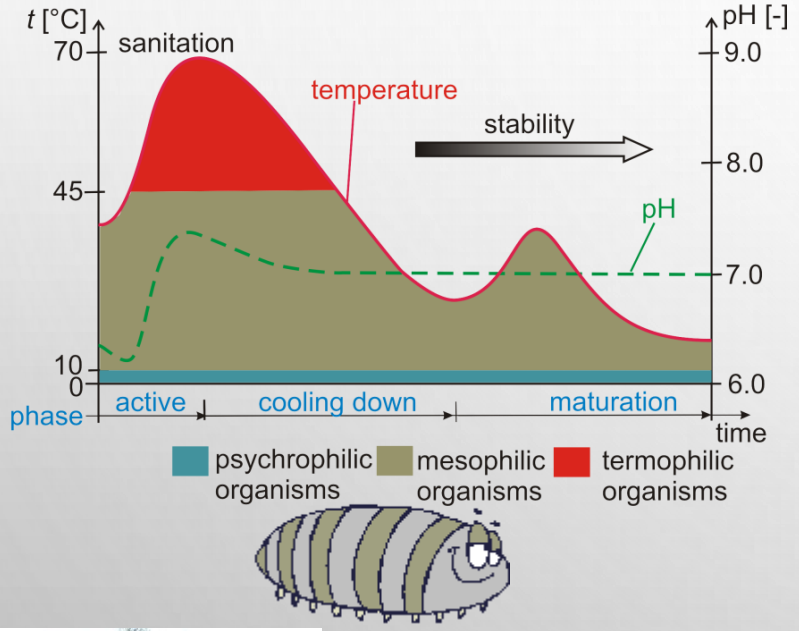


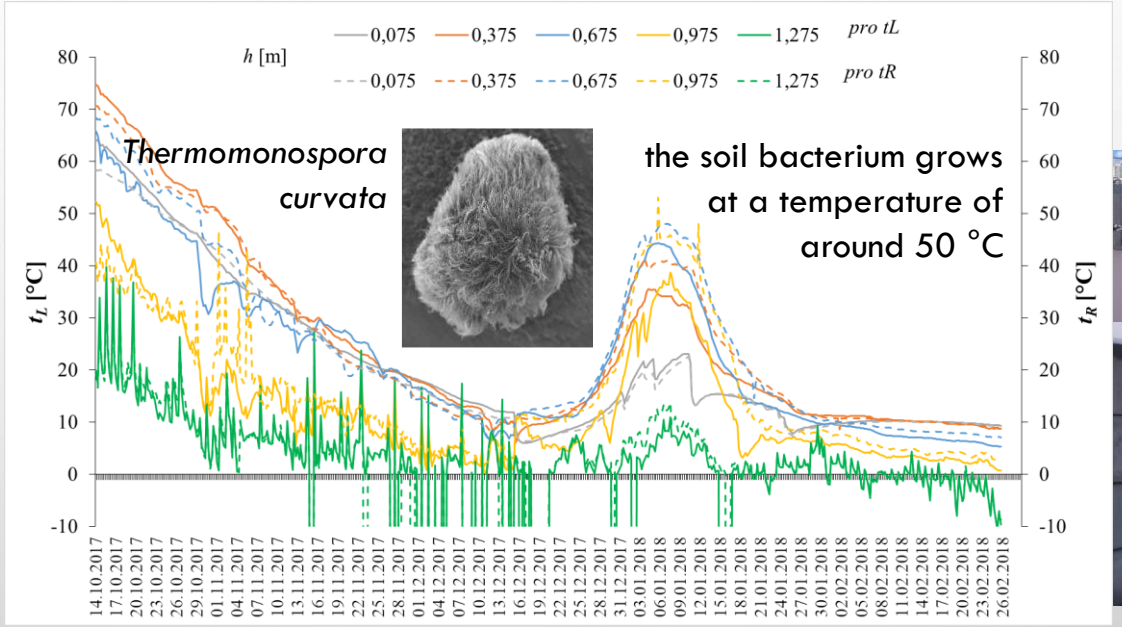


THE PROCESS OF COMPOSTING BIODEGRADABLE WASTE



Monitoring of the composting process - ZERA - Agricultural and Environmental Regional Agency, z.s. (Composting plant Vícenice near Náměšť over the Oslava river).





Nová technologie kompostování
CZ.01.1.02/0.0/0.0/15_019/0004646

EVROPSKÁ UNIE
Evropský fond pro regionální rozvoj
Operační program Podnikání a inovace pro konkurenceschopnost

MINISTERSTVO PRŮMYSLU A OBCHODU

ZERA

VUPT | Výzkumný ústav pícninářský spol. s r.o. Troubsko

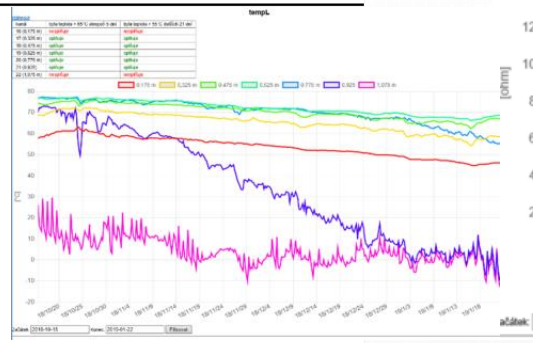
KATEDRA ENERGETIKY

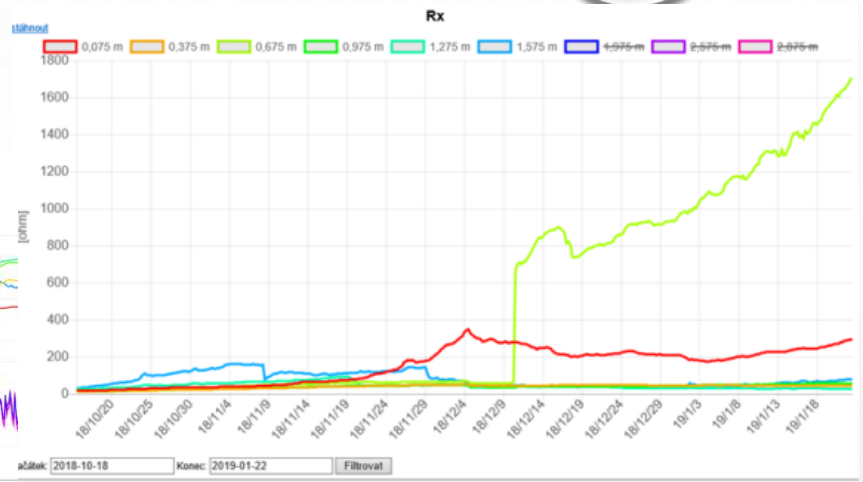
http://zera.artschool.cz/?loc=6

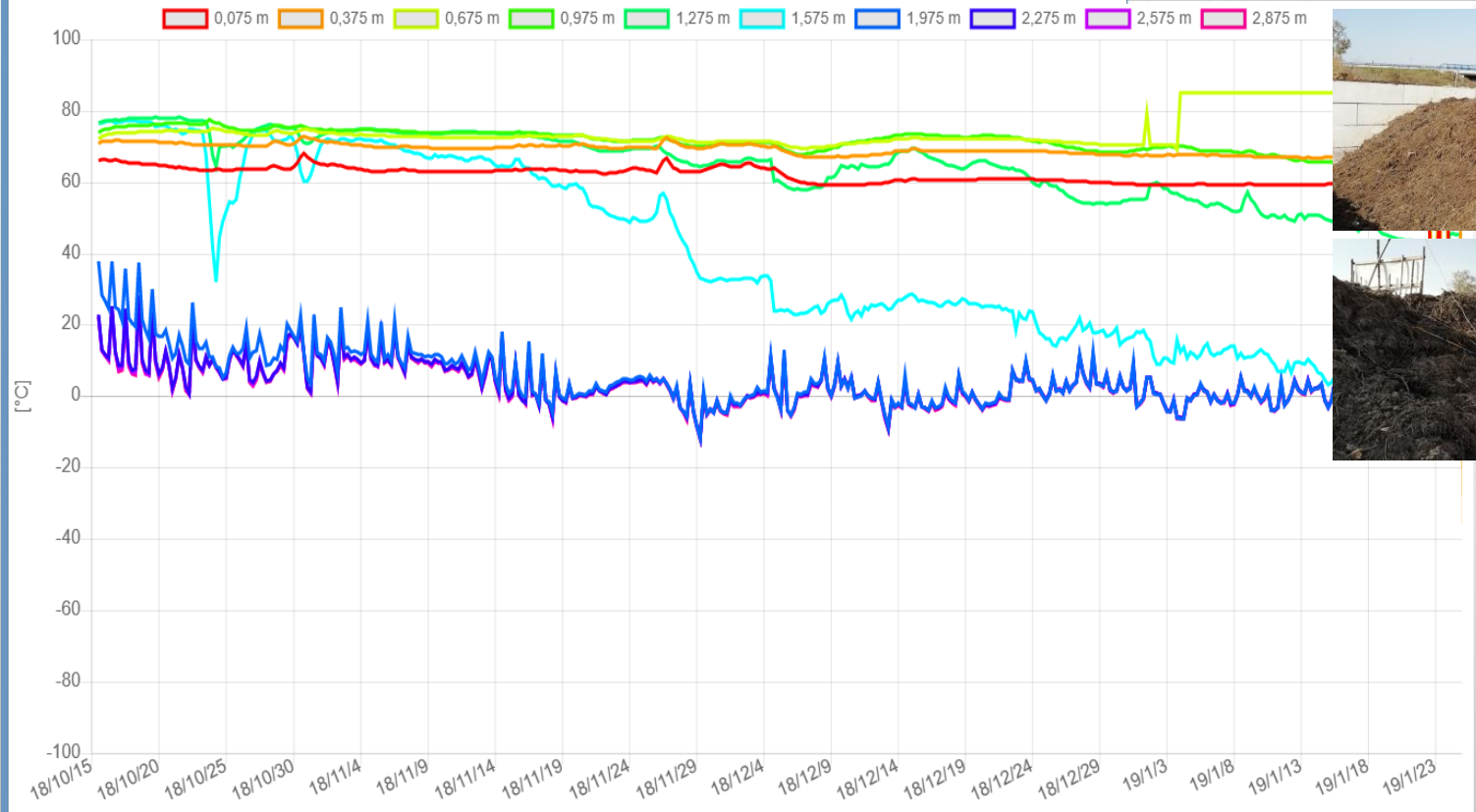
tempL

stáhnout

kanál	byla teplota > 65°C alespoň 5 dní	byla teplota > 55°C dalších 21 dní
0 (0,075 m)	nesplňuje	nesplňuje
1 (0,375 m)	splňuje	splňuje
2 (0,675 m)	splňuje	splňuje
3 (0,975 m)	splňuje	splňuje
4 (1,275 m)	splňuje	splňuje
5 (1,575 m)	splňuje	splňuje
6 (1,975 m)	nesplňuje	nesplňuje
7 (2,275 m)	nesplňuje	nesplňuje
8 (2,575 m)	nesplňuje	nesplňuje
9 (2,875 m)	nesplňuje	nesplňuje







Crushing and blending matter

Stack Building, Aeration

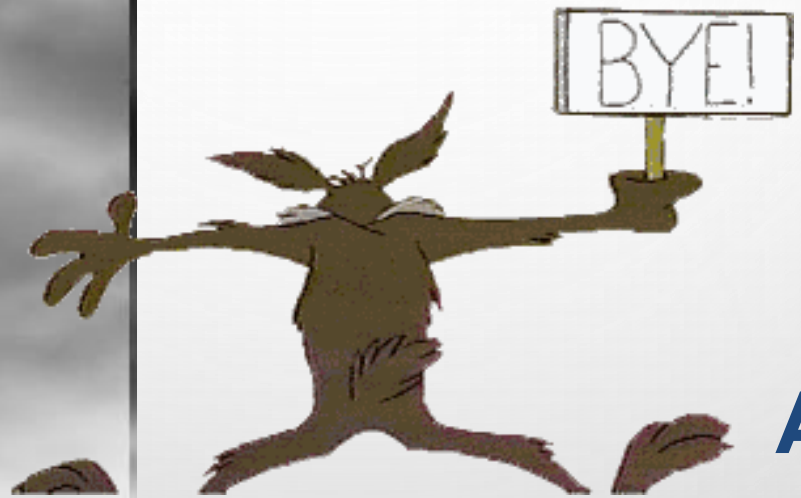
Temperature, „moisture" and „oxygen" recording

Delivery

Organic Waste collection household biowaste + „green matter"

Screening, Quality control, if required, Bagging

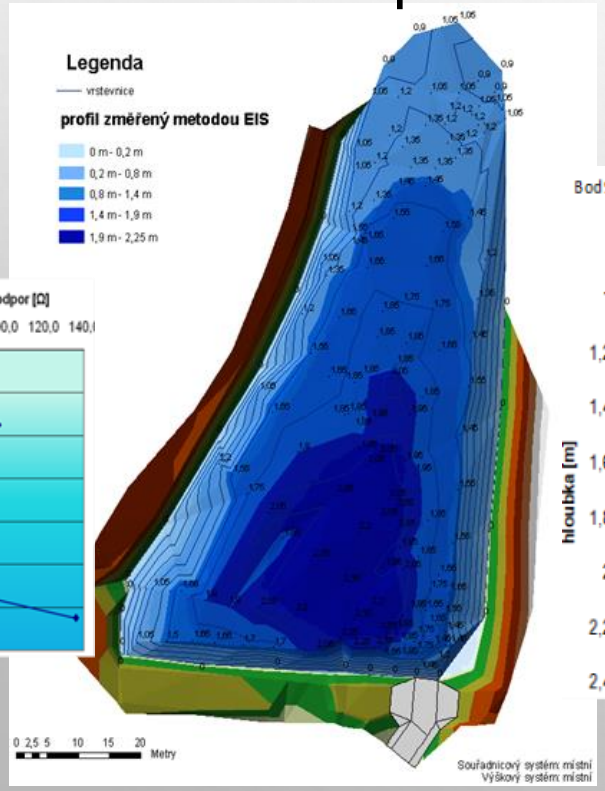
Watering and turning

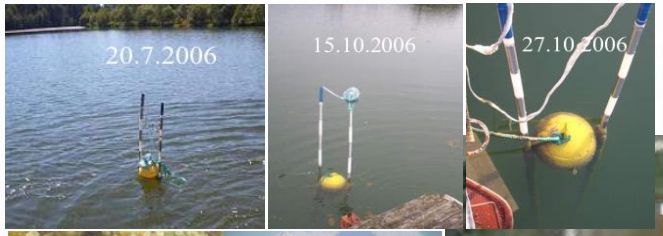


AND THIS IS THE END,
THANKS FOR YOUR TIME.

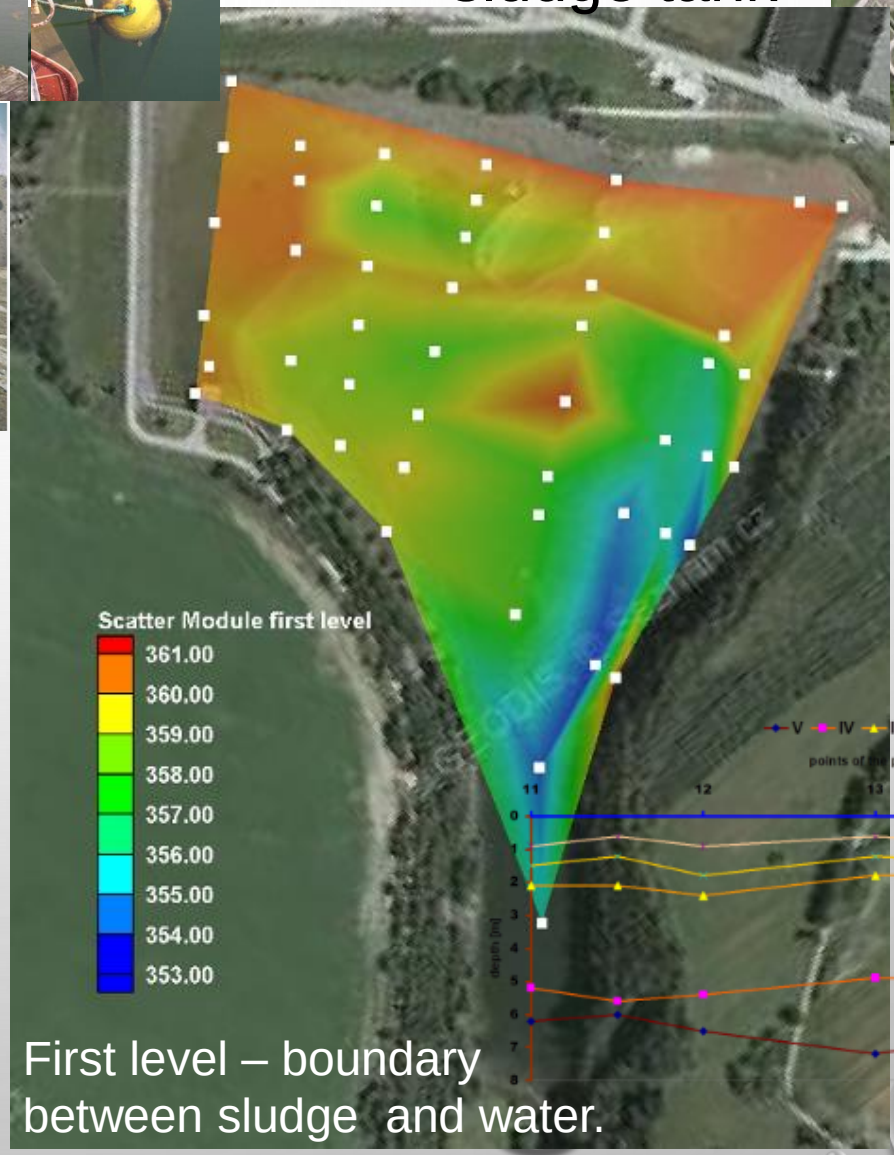
CLOGGING PROCESS OF TANKS (SLUDGE, POND)

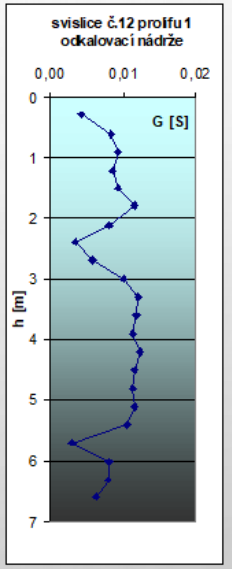
WS Kobeřice – pond tank





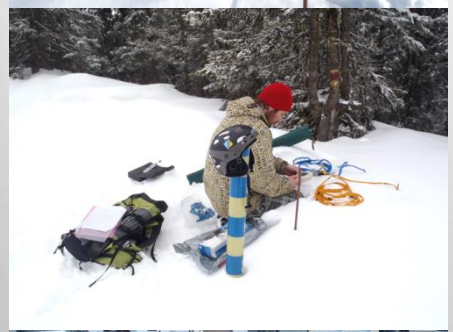
WS Rýzmburk – sludge tank





First level – boundary between sludge and water.

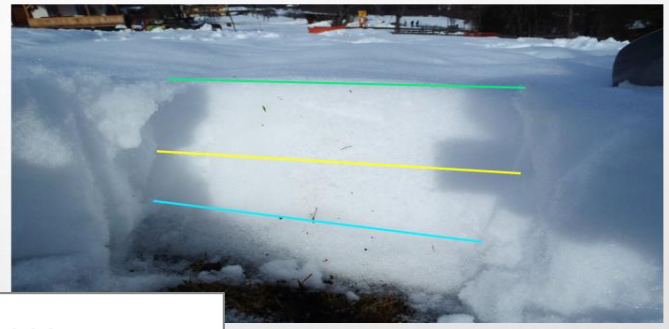
MONITORING OF SNOW COVER

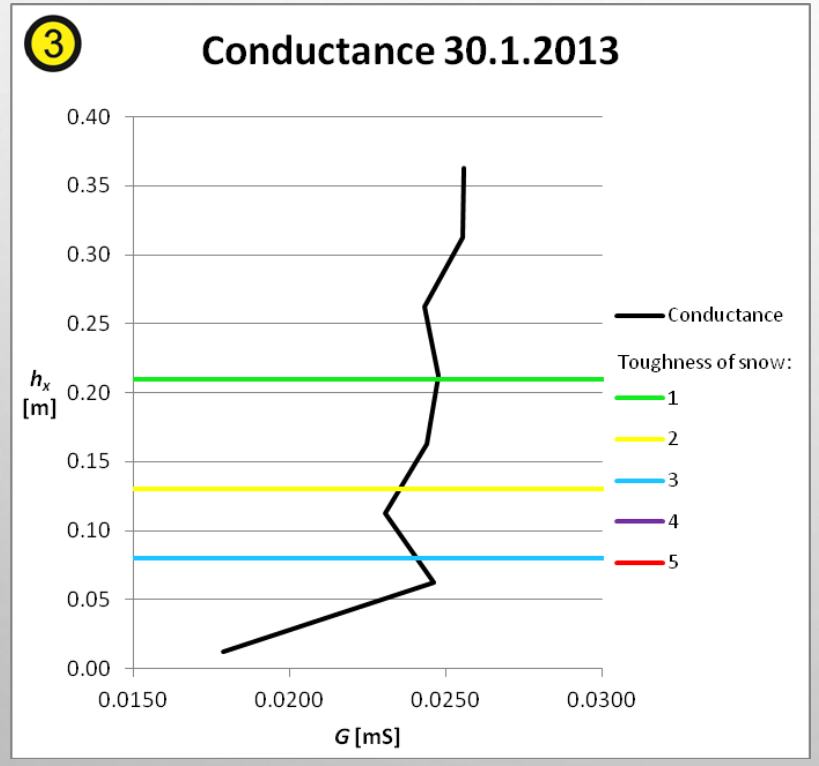


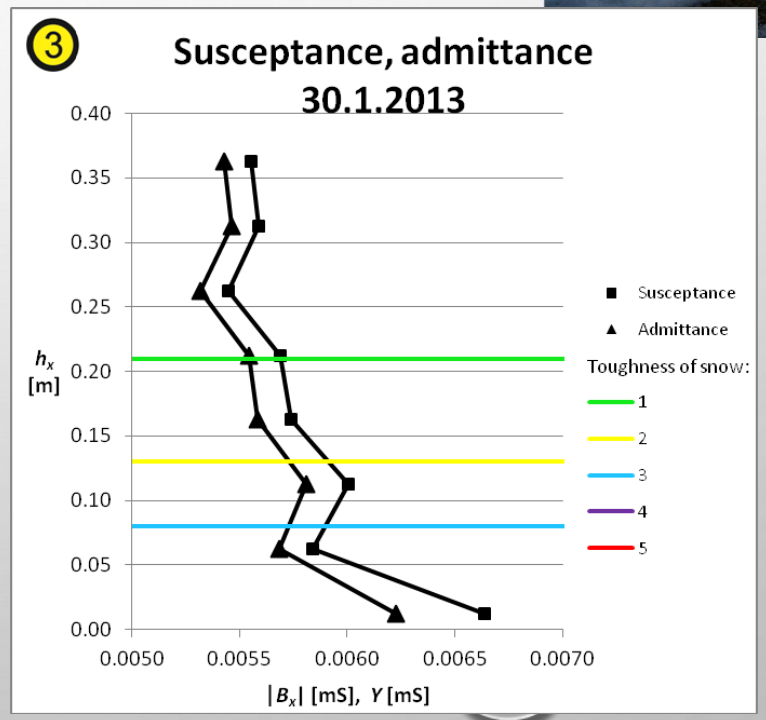
Measurement of bulk density of snow in different layers using weighing snow gauge and shovel, manual differentiation of snow toughness (Austria, Finland, Czech Republic).

Touhgness	Test of toughness	Resistance R (mean values)	No	Color
Very soft	fist	20 N	1	
Soft	four fingers	90 N	2	
Medium hard	one finger	260 N	3	
Hard	pen	600 N	4	
Very hard	knife	900 N	5	
Ice	ice		6	

$$\mathbf{Y} = \frac{1}{\mathbf{Z}} = \frac{1}{R + jX} = \frac{R}{R^2 + X^2} + j\frac{-X}{R^2 + X^2}, \qquad B = \mathrm{Im}(Y) = \frac{-X}{R^2 + X^2} = \frac{-X}{|Z|^2}.$$







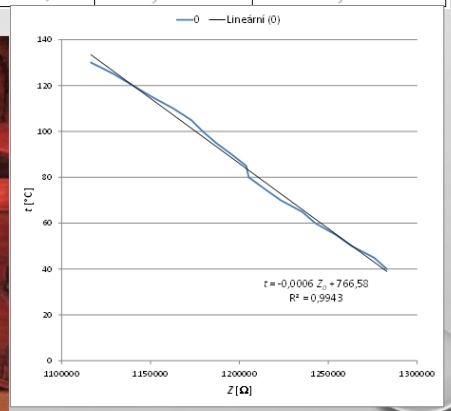
3 – LAYERS OF SNOW.

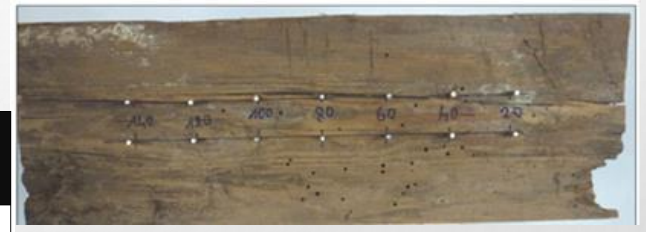
WOOD MONITORING – BURNING, THERMO REMEDIATION

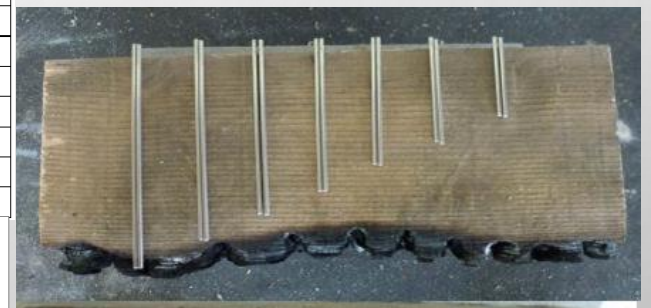
The measured electrical quantity is influenced by other physical factors **internal** – given by material properties (type, density, structure, anisotropy, temperature, wood defects, age, …) and **external** – define the measurement conditions (frequency and intensity of electric field, relative air humidity, chemical contamination of wood, air velocity, season, etc.).

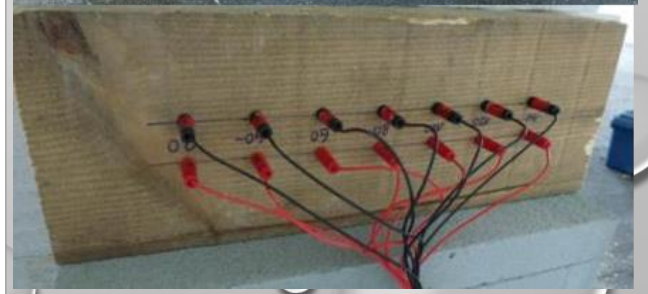
Two wooden blocks of spruce beams of the same dimension (0.175 m wide, 0.195 m high and 0.500 m long), but of different age, texture and structure.

Probe number	Active length of probe	Linear regression function	Value of reliability R^2	Temperature range of calibration
[-]	[m]			[°C]
0	0,18	$t_0 = -0{,}0006\ Z_0 + 766{,}58$	0,9943	<40°C; 130°C>
1	0,16	$t_1 = -0{,}0007\ Z_1 + 843{,}32$	0,9875	<40°C; 130°C>
2	0,14	$t_2 = -0{,}0007\ Z_2 + 867{,}54$	0,9942	<40°C; 130°C>
3	0,12	$t_3 = -0{,}0008\ Z_3 + 943{,}63$	0,9930	<40°C; 130°C>
4	0,10	$t_4 = -0{,}0006\ Z_4 + 794{,}62$	0,9886	<45°C; 130°C>
5	0,08	$t_5 = -0{,}0007\ Z_5 + 887{,}49$	0,9858	<45°C; 130°C>
6	0,06	$t_6 = -0{,}0007\ Z_6 + 971{,}69$	0,9944	<45°C; 130°C>

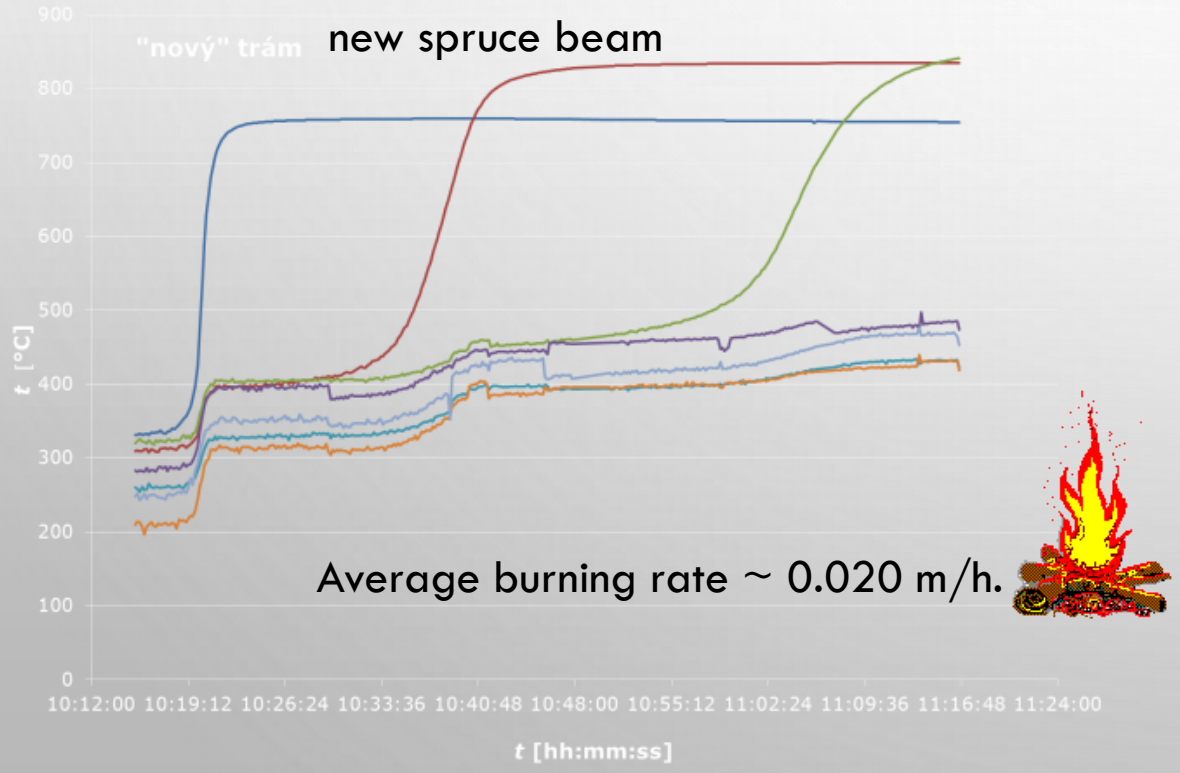






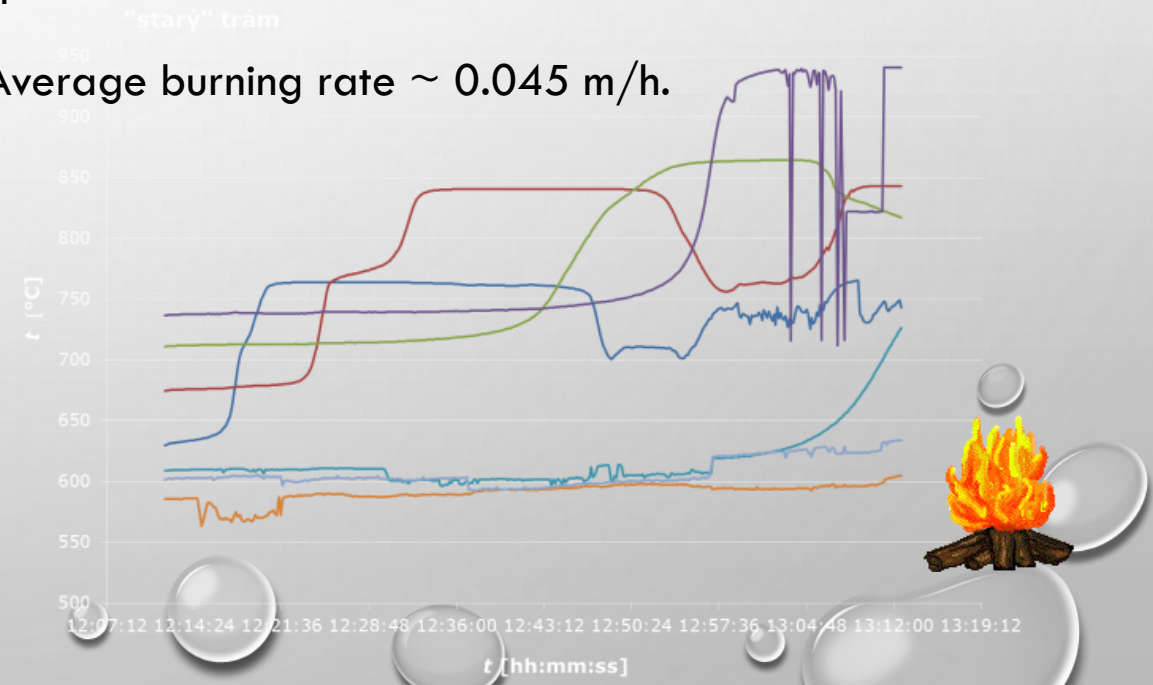


new spruce beam



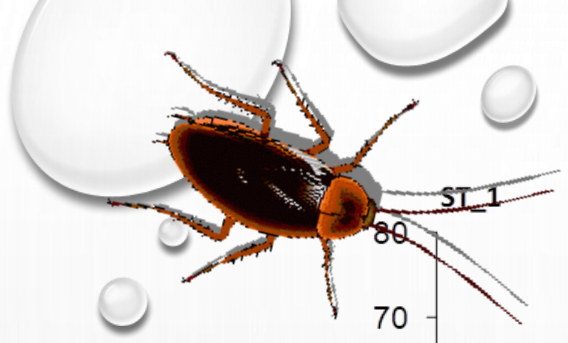
Average burning rate ~ 0.020 m/h.

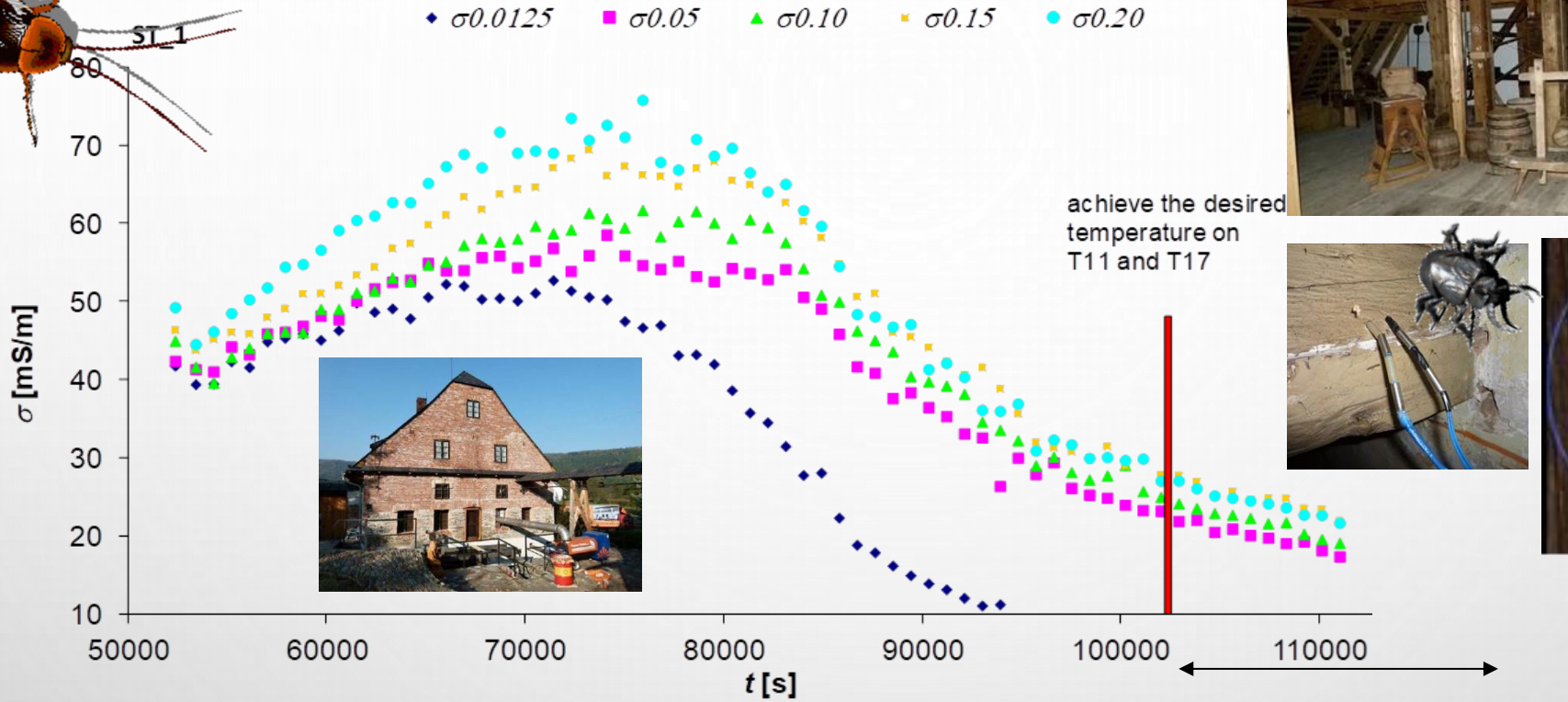
old spruce beam



Average burning rate ~ 0.045 m/h.

OAK BEAM

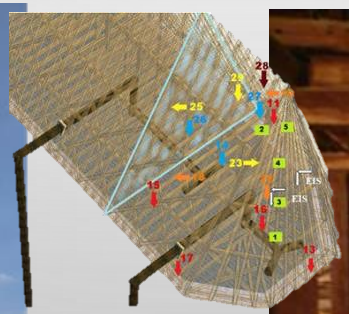




achieve the desired temperature on T11 and T17

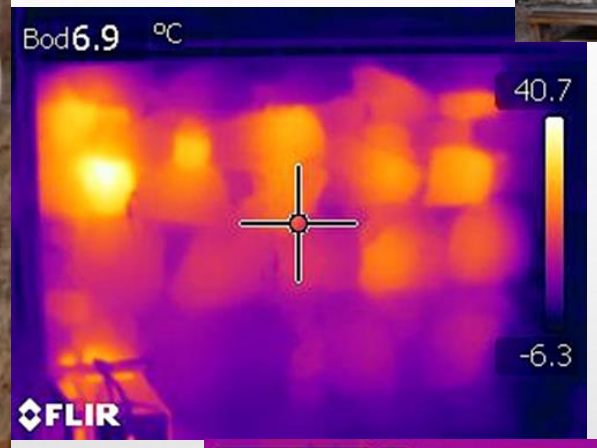
The moisture first diffuses in the direction of the beam axis and then outwards.

Uniform drying in all layers.

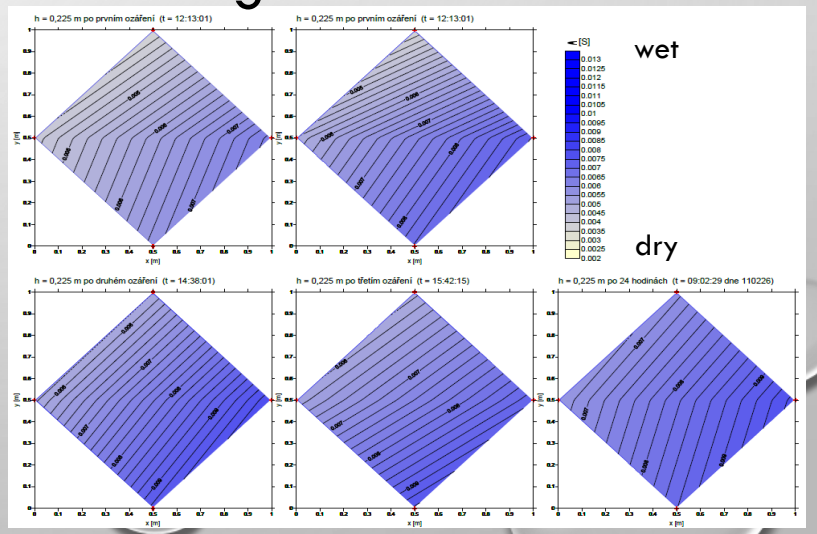


RESEARCH TOPIC - THE UNKNOWN MOISTURE MASONRY

Castle walls are of stone and brick.
Wall thickness was about 1.5 m below.
Composition of the walls is unknown (homogen
inhomogeneous, binder, plaster, ...).

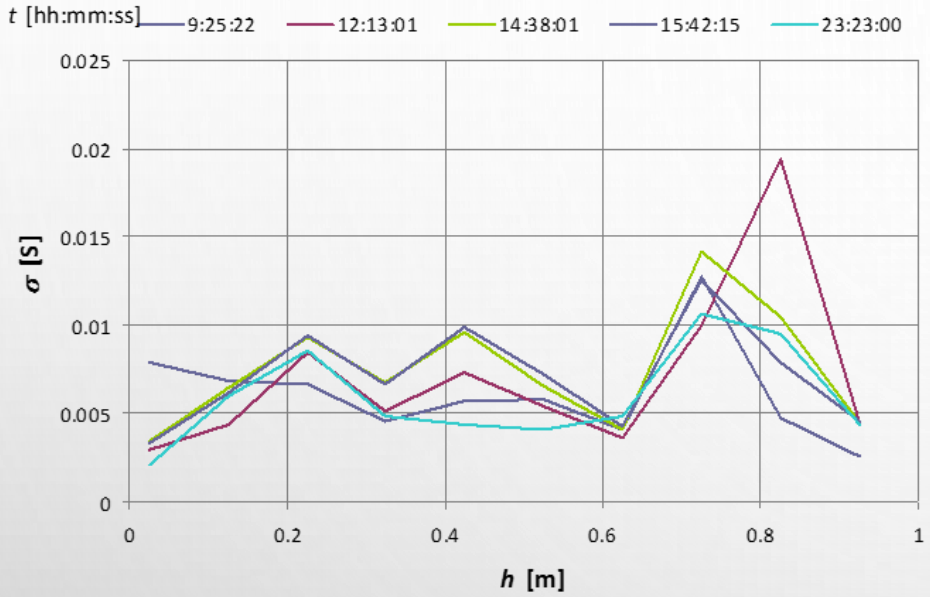


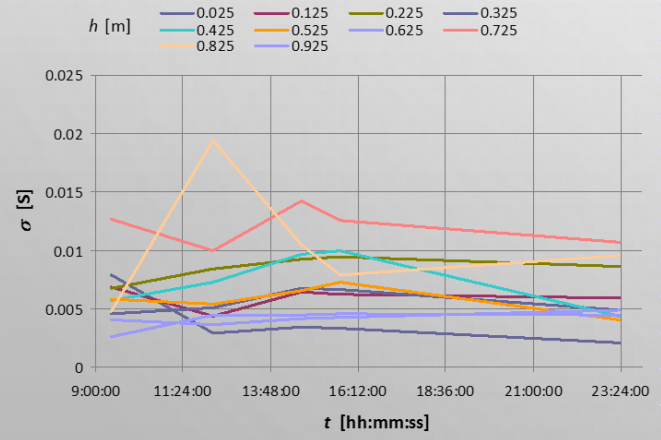
Temporal changes of electrical conductivity at a depth of $h = 0.225$ m below the surface after applications of microwave heating.

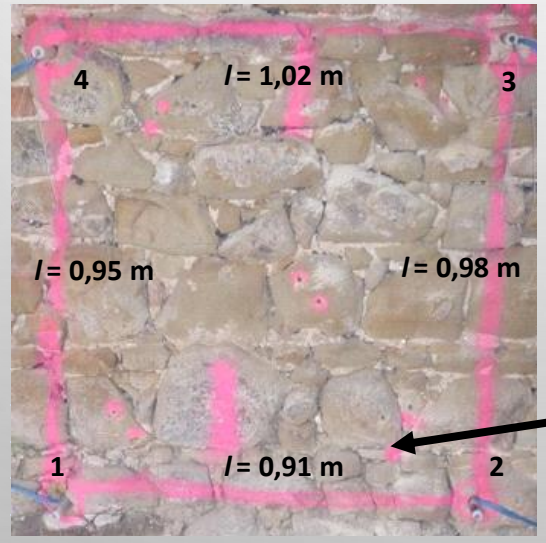


MONITORING OF MOISTURE IN WALL

Profile 1 - 2







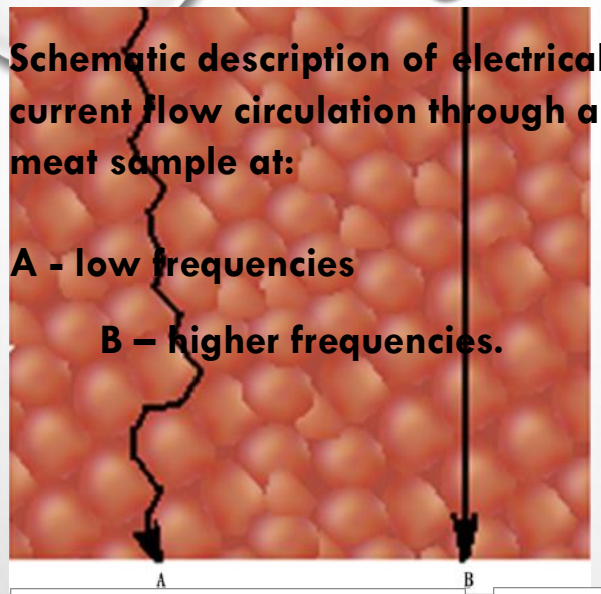
- Microwave applications.
- Heating 2 minutes with power 2 kW at one point, heated area was given an applicator used (the generator it was 0.18 m × 0.18 m and near the wall 0.47 m × 0.39 m), total were measured 20 points.
- Frequency microwave generator 2.45 GHz was used, which is equivalent to the wavelength of electromagnetic waves 0.1225 m.
- Wall surface temperature was measured infrared pyrometers GIM 530 MS (0 °C before heating and around 30 °C after heating), measurement at one level below the surface was used analog thermometer PU 521 with thermocouple.
- Power density of electromagnetic field radiation near the generator was controlled by device MLT 4th .
- Moisture in one level was measured by the device Hydromette 4050.
- Impedance in different level of the wall was measured by Z-meter III.
- Different length of „cable" pointed to the measurement of conductivity.

ELECTRICAL IMPEDANCE AS THE TOOL FOR EVALUATION OF BEEF MEET AGING

Schematic description of electrical current flow circulation through a meat sample at:

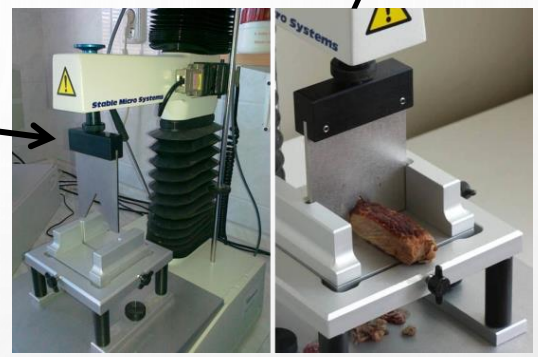
A - low frequencies

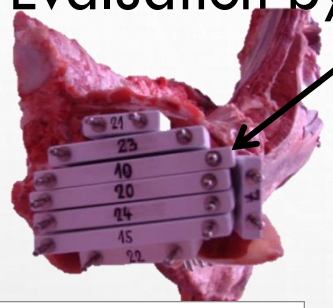
B – higher frequencies.



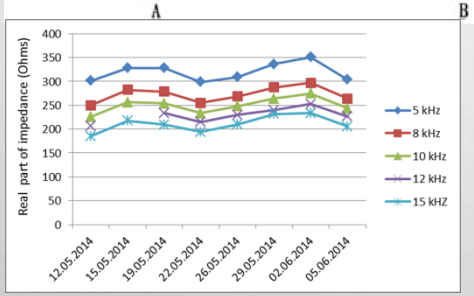
Measurement of tenderness is based on internationally standard Werner –Bratzler method.

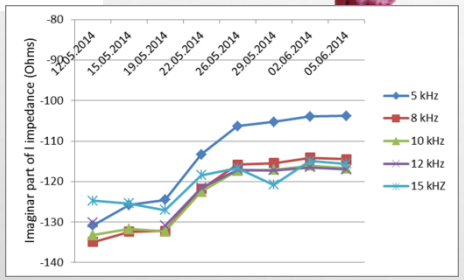
Evaluation by EIS method.





Limousine bull and Charolais bull were tested.





*Statistical evaluation_level of significance **1%, * 5%.*

Frequency	5000 Hz		8000 Hz		10000 Hz		12000 Hz		15000 Hz	
Impedance	R	I	R	I	R	I	R	I	R	I
Charolais	0,9270	-0,9532	0,8548	-0,9586	0,7948	-0,9607	0,7188	-0,9621	0,6411	-0,9631
	**	**	**	**	*	**	*	**	ns	**
Limousine	-0,2465	-0,9560	-0,3932	-0,9393	-0,4879	-0,9218	-0,7300	-0,8608	-0,5552	-0,8223
	ns	**	ns	**	ns	**	*	**	ns	*

Overall conlcusions from existing literature:

At low frequencies in the range from 1 to 10 kHz, the current is hardly able to pass through the cell membranes. It therefore crosses the ECF and contains practically no reactance component. For this reason, these frequencies can be used selectively to calculate the extracellular water volume **- HAS TO DO WITH AGING (AND INCREASE OF TENDERNESS)**

Taken from : Y. Yang et al., Mathematical and Computer Modelling 58 (2013) 819–825

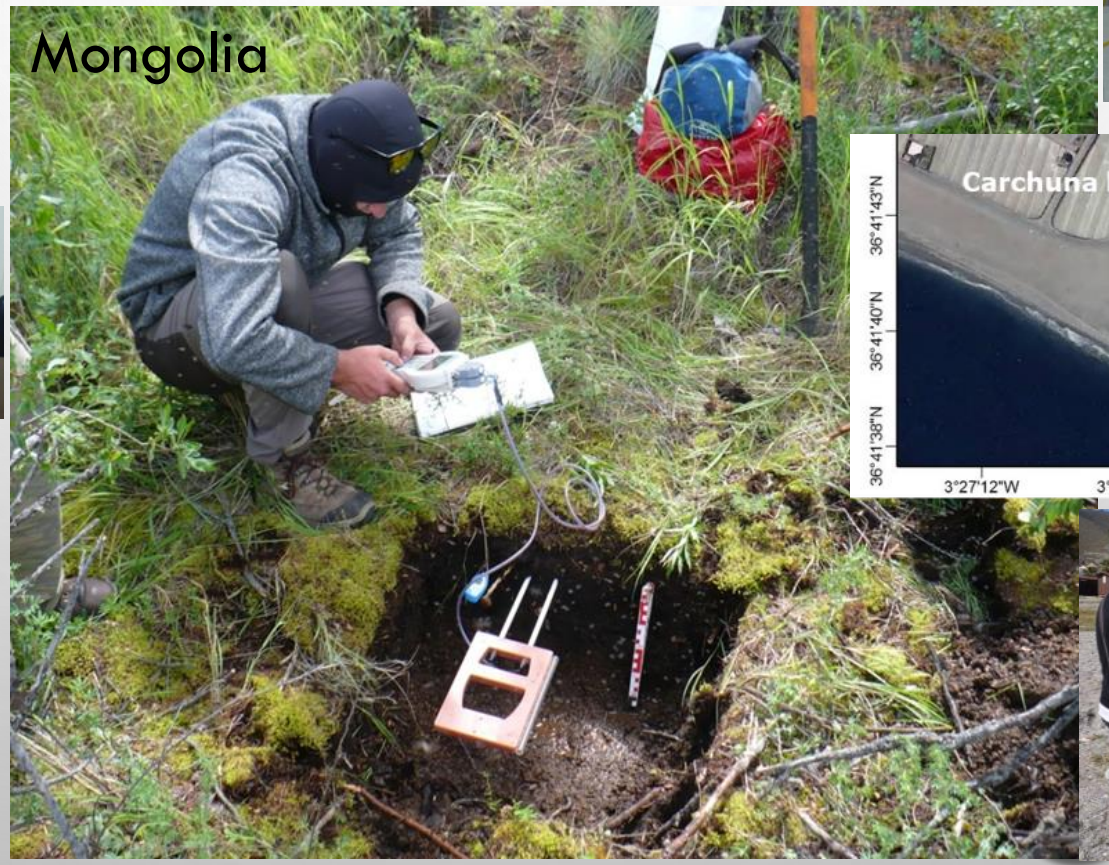
With increasing frequency, up to 50 kHz, the current is able to penetrate the cell. Therefore, at frequencies around 50 kHz, measurements of the total body water volume and body cell mass can be made **- HAS TO DO WITH THE ENTIRE WATER CONTECT (AND ARTIFICAL ADDITIONS)**

MONITORED SITES

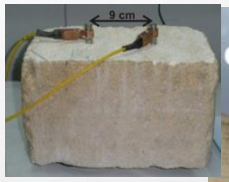
CZ – GEO*test*, a.s., Karolinka, WWT Modřice, Bystrc, Náměšť nad Oslavou, Rýzmburk, Rychvald, Lutyně, Kozlovice, Štramberk, Žabčice, Svratka, Kunětická Hora, Jevíčko, Kobeřice, Hornice …. SK – Milhostov, Velké Ripňany, sv. Martin Bratislava, Senné, Nitra, IT – Bari, CH – Basel, B – Oostende, BG – Varna, Sofia, LV – Riga, LT – Kaunas, Moldova – Chisinau, Philippines – Manila, EP – Granada, Barcelona, PT - Lisboa (cooperation realized through teaching), UA – Ternopil, Rivne, Nicaragua, China and Mongolia.

Manila - Philippines

Nicaragua



Mongolia



Canosa di Puglia, IT

Sierra Nevada, ES