Polish Society of Soil Science

INTERNATIONAL SYMPOSIUM OF SOIL PHYSICS

Organizers:

Section Soil Physics, Polish Society of Soil Physics

Lithuanian Soil Science Society

Faculty of Civil and Environmental Engineering,

Warsaw University of Life Sciences – SGGW

Warsaw University of Life Sciences (SGGW)

11 February, 2016

Symposium program

11 February, 2016

Laboratory Water Centre (Laboratorium Centrum Wodne) SGGW, building 49, 6 Ciszewskiego str.

8.55	Opening the symposium
9.00 – 10.30	Presentations (chairmen – Andrzej BIEGANOWSKI)
9.00	*The activity of Lithuanian Soil Science Society in the context of different soil schools of Lithuania.* Jonas VOLUNGEVIČIUS, Rimantas VAISVALAVIČIUS, Inga LIAUDANSKIENĖ
9.15	*New trends in soil magnetometry.* Tadeusz MAGIERA
9.30	*ASU research possibilities for international cooperation.* Zita KRIAUČIŪNIENĖ
9.45	*The application of physical methods in assessing the properties of humic substances terrestrial and aquatic ecosystems.* Lilla MIELNIK, Romualda BEJGER
10.00	*Institute of Agroecosystems and Soil Science: potential of research.* Vaclovas BOGUŽAS
10.15	*Measurements of soil splash phenomenon in micro scale.* Magda RYŻAK, Michał BECZEK, Andrzej BIEGANOWSKI
10.30 – 11.00	Coffee break (tea drinkers will be not discriminated)
11.00 – 12.45	Presentations (chairmen – Rimantas VAISVALAVIČIUS)
11.00	*Soil research activities at Lithuanian Research Centre for Agriculture and Forestry.* Virginijus FEIZA
11.15	*Soil hydrophobicity - determination methods and their compatibility.* Ewa PAPIEROWSKA, Jan SZATYŁOWICZ, Barbara KALISZ, Andrzej ŁACHACZ, Wojciech MATYSIAK
11.30	*Integrated studies of Lithuanian forest soils.* Dovilė ČIULDIENĖ
11.45	*Selected hydrophysical properties of garden soils in Krakow.* Michał GĄSIOREK
12.00	*Geological laboratory capacities for rock and soil physical-mechanical investigation.* Mindaugas PETRAUSKAS, Romuald RAKALOVIČ
12.15	*Development of integrated geophysical/geochemical methods of soil and groundwater pollution assessment and control in problematic areas" (IMPACT).* Marzena RACHWAŁ, Tadeusz MAGIERA
12.30	*Crop, water, soil under changing climate – evidence from long term experiments.* Virmantas POVILAITIS
12.45 – 13.15	Coffee break (tea drinkers will be not discriminated)

13.15 – 14.35 Presentations (chairmen Jan SZATYŁOWICZ)

13.15 *Soil water dynamics during precipitation in genetic horizons of Albeluvisols.* Tomasz ZALESKI, Mariusz KLIMEK

13.30 *Functional and Structural Succession of Soil Microbial Communities in Ploughed and Naturally Developed Soils.* Jūratė ALEINIKOVIENĖ

13.45 *Potential of visible and near-infrared spectroscopy as a rapid tool to determine several soil properties at different scales: from the field to a Polish spectral database.* Guillaume DEBAENE, Jacek NIEDŹWIECKI

14.00 *Spatial differentiation of selected physical properties of soils derived from loess.* Ryszard MAZUREK, Tomasz ZALESKI, Christian SCHNEIDER, Mirosław ZAGÓRDA, Krzysztof TOMASIK, Jarosław WAROSZEWSKI

14.15 *The representativeness of soil spectra obtained by proximal sensing measurements in estimation of soil properties.* Karolina HERODOWICZ

14.30 *Hydrophysical properties of arctic soils developed on micro-relief forms.* Piotr BARMIŃSKI

14.45 Summary and closing

14.50 A common move to the Crystal Auditorium for lunch

(building 9, 161 Nowoursynowska str.)

List of abstracts:

List of participants

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Abstracts

The activity of Lithuanian Soil Science Society in the context of different soil schools of Lithuania

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Key words: soil, classification, resources, quality and productivity.

Lithuanian Soil Science Society (LSSS) was set up in 1958 as a branch of Soil Science and Plant Nutrition Society in former USSR. Since 1990 it was recognized as independent body and finally (in 2005) LSSS was registered at the Department of Agriculture and Forestry of the Lithuanian Academy of Sciences. Today society unites more than 100 individual members from state universities, research institutes, land service and other organizations. It is associated member of International Union Soil Sciences (IUSS) and European Union Soil Sciences (EUSS).

Among the tasks of Lithuanian Soil Science Society − popularization and exchange of the newest scientific information; promotion and coordination of interinstitutional investigations; organisation and execution of scientific conferences, seminars, fieldtrips; support for consultations, training visits and other contacts with foreign Soil Science Societies and Associations. It is worthy to note, that in recent years LSSS is being focused very much on the efforts to share the knowledge of different soil science schools in order to generate qualitatively new complex ideas for frontier research projects.

Historically there are formed two main soil science schools in Lithuania: an agronomic − focused on the knowledge of soil profile identification and productivity solutions and geographic one – with much higher priority to soil genesis and its regional characteristics research. In total about 14 institutions and other bodies in Lithuania could be mentioned as less or more involved in various soil-related issues (investigation, conservation and etc.). However, the main institutional and ideological centers are concentrated in Vilnius University (Department of geography and land management), Aleksandras Stulginskis University (Institute of Agroecosystems and Soil Science) and Lithuanian Research Centre for Agriculture and Forestry (in particular, the Lithuanian Institute of Agriculture and Agrochemical Research Laboratory).

Several trends and directions were highlighted in recent years as a result of the collaboration between the different Lithuanian academic / soil science schools and other institutions:

Development and update of the Lithuania soils classification and regionalization.

Expeditionary field survey (fieldtrips) for the identification and analysis of soil profile morphological, physical and chemical properties / characteristics in relation to soil-forming processes.

New trends in soil magnetometry

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Following the publication of Le Borgne from 1955, who found that soils very often have “enhanced” values of magnetic susceptibility in surface layers geophysists and soil scientists started the investigation of the soil magnetic properties. The first interpretation of this phenomena given by Le Borgne in 1960 was the forest fires, but some other authors found that the measurement of magnetic susceptibility and other magnetic properties can be used in soil sciences as an easy to measure indicator of some pedological processes including weathering, iron migration and neoformation of iron oxides and hydroxides, magnetotactic bacteria activity. Long after Le Borgne, indeed an example of purely pedological enhancement was published in a paper by Maher and Taylor, on the discovery of the formation of magnetite in soils that were known not to have any primary magnetite input (Maher & Taylor 1988). The reduction and subsequent oxidation of non-ferrimagnetic iron oxides in the soil in order to form ferrimagnetic minerals of the magnetite - maghemite series, was the explanation of these phenomena. Up to the end of 1980s mostly the natural iron minerals were considered as the source of magnetic signal in topsoil. The first who pointed out on the fact that at sites close to the major urban and industrial centres in central and northern England, surface soil have a higher magnetic susceptibility were Thompson & Oldfield. They suggested that it is result of fallout from the atmosphere of magnetic spherules derived from fossil-fuel combustion. The first institution where the intensive studies on anthropogenic input on soil magnetic properties were initiated at the end of 1980s was Institute of Environmental Engineering, Polish Academy of Sciences in Zabrze. At the same time the first publication by Prof. Strzyszcz and his teem arose. Currently the soil magnetometry is used in many countries to assess the concentration of technogenic magnetic particles (TMPs) as a tracer of industrial and urban dust deposition that results in topsoil magnetic anomaly. The magnetic anomaly of anthropogenic origin is usually associated with geochemical anomaly as the TMPs are carriers of many trace elements. Such anomaly can be easily detected using simple laboratory or field magnetic susceptibility meters (χ or κ respectively) and on this basis a degree of environmental pollution caused by industrial and urban dust deposition can be assessed. Detected in a such way magnetic anomaly is the warning signal of potential contamination of the study area by heavy metals and other soil pollutants. During the last decade annually 60 – 80 scientific papers related to soil, sediment or dust magnetism is published in environmental, soil sciences or geophysical journals. The most of them are related to spatial distribution of contamination in soil, the estimation of deposition rate, magnetic biomonitoring of deposition level, spatial range of emission. Currently studied problem is also diversification of geogenic, pedogenic, biogenic and anthropogenic magnetic signal measured in soil profile as well as relation of magnetic signal distribution with soil type.

Research possibilities at aleksandras stulginskis university for international cooperation

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Keywords: food sciences, agriculture, forestry, water and land resources management, bioenergy and mechanical engineering, climate change, sustainable use of natural resources, R&D Open Access Centres

Aleksandras Stulginskis University (ASU) is a state university established in 1924. Today it is the only state university in Lithuania awarding the diplomas and degrees at PhD, MSc and BSc levels in the fields of food sciences, agriculture, forestry, water and land resources management, bioenergy and mechanical engineering, climate change and sustainable use of natural resources. These degrees are recognized all over the world and have the highest standard of equivalence. The mission of ASU is focussed on creating and disseminating scientific knowledge, sincerely striving for safe and healthy food and full-fledged living environment for every citizen of Lithuania and of the global world. ASU is open to challenges and changes, adopting the best experience of the world universities, developing internationally, seeking continuous improvement and leadership among the best universities in the same field.

ASU employs a total of 900 staff, including over 300 teaching and research staff members and has close to 5000 students studying in five Faculties: Faculty of Agricultural Engineering; Faculty of Agronomy; Faculty of Economics and Management; Faculty of Forestry and Ecology; Faculty of Water and Land Management. The total of 14 institutes within the Faculties includes the researchers and teaching staff responsible for research and education.

ASU is proud of having a very modern research infrastructure in R&D Open Access Centres: Open Access Joint Research Centre of Agriculture and Forestry, and The Centre of Biosystems Engineering, Biomass Energy and Water Engineering, with more than 50 research laboratories in agriculture, forestry, water, biofuel and bioenergy, climate change, with equipment available for high quality field and laboratory experiments and research. The Centre of Communication and Technology Transfer including business incubator is available for bridging the research and business. The ASU Experimental Station and ASU Training Farm together with the Agriculture Science and Technology Park are the academic infrastructure units serving the field experiments, practical training and dissemination of knowledge. More information available on ASU webpage http://asu.lt/language/en/

The application of the physical methods in assessing properties of humic substances (HS) in terrestrial and aquatic ecosystems

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Humic substances are group of organic compounds formed by the association of high-molecular-mass substances from microbiological, vegetative and animal origin. They are organic macromolecules with multiple properties and high structural complexity. They exist abundantly in soil, natural water and various terrestrial and aquatic environments. Humic substances can be divided into components according to their solubility in different media. Humic acids and fulvic acids represent alkali-soluble humus fragments, humin represents the insoluble residue. Properties of humic substances are determined by the type of organic matter humified in the specific environment as well as various habitats related and anthropogenic factors which determine the direction of their transformation.

Humic substances exposed to light undergo photochemical processes accompanied by creation of the long-term fluorophores capable of producing electromagnetic radiation in the process of luminescence. The use of luminescence in testing organic substances of various origin may provide information about the structure and nature of organic links as well as photoreactivity of these substances. Additionally, based on findings from luminescence tests it is possible to determine changes which occur in those substances in time, in particular in the process of humification.

The luminescence methods – fluorescence (emission and excitation spectra, synchronous scan fluorescence spectra and excitation-emission matrix analysis) and delayed luminescence can play a major role in testing humic substances from various ecosystems, especially that these methods are exceptionally sensitive, easy and quick. Appears to be, this should save time and cost of such tests. The luminescence methods may significantly reduce the number of analyses and loss of information necessary to draw conclusions.

Measurements of the soil splash phenomenon in a micro-scale

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Soil, a natural product of the top layer of the Earth's crust, serves multiple important functions in ecosystems. Thanks to its retention capacity, soil plays a significant role in the water cycle in nature; it also is a landscape-shaping element and a basis for crop production. Soil is exposed to various factors that can cause degradation thereof. One of these factors is soil erosion. Erosion is a physical degradation process affecting the soil surface. This process affects not only the environment, but also the productivity and profitability of agriculture. Therefore, understanding and preventing the mechanisms of erosion is important for agriculture and economy. Many factors induce erosion, including water or wind activity, and it can be further aggravated by inappropriate agrotechnical practices. Due to large economic and natural losses caused by erosion, the problem has been investigated by many research teams worldwide.

Soil splash is one of the phenomena accompanying the impact of a drop of water on the soil surface, which can break down soil aggregates, thereby generating sediment for transport. Most research focuses on splash measurements based on the analysis of the mass of material transferred and is available for execution only when the amount of the transferred material is large enough to make it measurable.

The aim of our study was to develop measurement methods that could characterize the splash phenomenon in a micro-scale induced by even one drop and would be independent of the weight of dispersed material.

We used three methods that can describe soil splash in a micro-scale:

analysis of microscopic images – this method allowed determination of such parameters as the surface area of splash tracks, the surface area of the dispersed solid phases, determining its distances and ratio in the water and solid phase on the tracks [Ryżak and Bieganowski, 2012];

a set of high-speed cameras with specialized software – this method allowed the observation of the phenomenon of splash and parameterization thereof by specifying the parameters of the crown, tracking the path of splashed particles, and determining their range and speed [Ryżak et al., 2015];

dynamic force sensor – this method allowed determination of the impact force of falling water droplets that initiates soil splash [Korbiel et al., 2015].

The proposed measurement methods ensure a comprehensive analysis of the phenomenon of splash caused by the impact of even a single drop on the soil surface.

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Soil research activities at the Lithuanian Research Centre for Agriculture and Forestry

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Lithuanian Research Centre for Agriculture and Forestry was established in 2010 as a merger of three related research institutions: Lithuanian Institute of Agriculture, Lithuanian Institute of Horticulture and the Lithuanian Institute of Forestry.

Lithuanian Research Centre for Agriculture and Forestry carries out the long-term research programme "Productivity and sustainability of agricultural and forest soils". Some research directions:

- Selection of crop management systems, crop rotations and their sequences;
- Effects of soil tillage on the variation of soil physical properties under changing climatic conditions;
- Development of ploughless tillage system and identification of the applicability for no-till for individual agro zones of the country.
- The influence of cropping systems on soil water retention properties and hydraulic conductivity in relation with soil C.
- Investigation of carbon dioxide emission and other (CH_4, SO_4, O_2) gases investigation under different soil management on *Cambisol*.
- Improvement of physico-chemical soil properties of acid *Alboluvisols* and crop productivity.

Fig. Laboratory for soil physical properties investigations at the Department of Soil and Crop Management

Soil hydrophobicity - determination methods and their compatibility

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The phenomenon of hydrophobic soils is a problem frequently encountered in mineral as well as in organic soils. The correct recognition of soil hydrophobicity and its distribution is necessary to predict and prevent from its negative effects such as changes in ecosystems, leading to their degradation. Moreover hydrophobicity significantly affects water infiltration into the soil. In case of high rainfall reaching the surface of hydrophobic soils a layer of water on the ground surface is very quickly being formed causing different types of erosion.

Comparison of hydrophobicity assessing methods were studied by many authors. However, the results obtained using different methods may be incomparable and often indicate at different degrees of hydrophobicity in the same soil formations. In the literature there is lack of objective criteria for selection of soil hydrophobicity measurements method.

The aim of this study was to compare methods utilized for assessing soil hydrophobicity using statistical method called "agreement between observers" which is based on measuring the weighted kappa coefficients. The study covered 106 soil samples which were collected from north-eastern Poland. The soil samples were characterized by varying degrees of hydrophobicity. Only air-dry soil samples were used.

In order to assess soil wettability the contact angle was measured using sessile drop method with a goniometer CAM 100 (KSV Instruments) and the Wilhelmy plate method with the measuring set DCAT 11 (Dynamic Contact Angle Meter and Tensiometer). The wetting contact angles were determined at room temperature (20ºC) within 10 min after sample preparation using standard procedure. In addition, water drop penetration time and the alcohol percentage tests were conducted. Weighted kappa coefficients were calculated using SAS 9.4 (SAS Institute, 2013, Cary NC).

The performed analysis showed that, the agreement between considered methods of the contact angle measurements shows strong relationships although a different value of the contact angle were measured. There was also a high agreement between the water drop penetration time test and the alcohol percentage test. The results of agreement were presented in forms of agreement charts.

Integrated studies of Lithuanian forest soils

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Amongst key environmental services provided by the Nordic and Baltic forests are carbon sequestration, water protection and biodiversity - all linked to the quality of soil. We present objectives and achievements from three Lithuanian studies: **(1) Soil organic carbon (SOC) sequestration:** SOC stability in nutrient-poor *Arenosols* and nutrient-rich *Luvisols* under different land-use (forest, arable land, afforested arable land, perennial grassland in abandoned arable land) was identified according to the contents of: (a) unprotected SOC, which consisted of water extractable SOC and soil microbial biomass carbon (SMB-C); (b) unprotected SOC and being physically protected from microbial decomposition; and (c) chemically and biochemically protected SOC. We found that mineral topsoil in afforested arable land along with the highest concentrations of SOC and SMB-C distinguished with the highest contents of SOC protected in SOM of silt + clay (<53 μm) fractions. **(2) Water protection/clean water:** Analyses of soil solution indicated that leaching may cause increased groundwater concentrations of nitrate (NO^{-}_{3}), nitrite (NO^{-}_{2}), potassium (K^{+}), dissolved organic carbon (DOC) and phosphates (PO^{3-}_{4}) in fresh clear cuttings of coniferous stands, especially skid trails. The leaching of nutrients from arable land with organic farming was similar, except that more DOC was leached in the adjacent forest stands. **(3) Soil quality/ climate change:** We estimated mineral weathering rate expressed as sum of cations (Ca^{2+}, Mg^{2+}, K^{+}) release rate through the soil profile mmol m^{-3} yr^{-1} in different warmth-tolerant tree species plantations. The 47 and 157-year-old European larch (*Larix decidua* Mill.), 45 and 55-year-old Northern red oak (*Quercus rubra* L.) plantations and adjacent perennial grasslands were chosen for this study. The soils were classified as *Luvisols* and were developed from glaciofluvial deposits. A 30% higher sum of cations (Ca + Mg+ K) release rate in soil under the Northern red oak than in adjacent perennial grassland was estimated. Meanwhile, aforementioned parameter in differently-aged European larch plantations does not differ much. The obtained results suggest that low calculated rates of cation release 13.1±0.4 mmol m^{-3} yr^{-1} in grassland and stable 62.3±7.4 mmol m^{-3} yr^{-1} observed in differently-aged larch plantations could sustain the quality of soil. The higher mineral weathering rate in the Northern red oak forest ecosystem could be related with a faster nutrient cycling.

Selected hydrophysical properties of garden soils in Krakow

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Many centuries of human activity, which includes also the horticultural cultivation leads to numerous changes in soil. In the case of large cities, one cannot forget about the transformations caused by the widely understood urbanization. Above mentioned transformations significantly affect the soil properties, therein hydrophysical ones.

The present study focused of determining the effect of long-term horticultural use on some physical properties of the soil in urban area on the example of Krakow.

The study was conducted in the four convent gardens in Krakow. Three of them (Carmelites, Capucins and Bernardines) were located in the historical centre of the city and one – Benedictines convent garden, in Tyniec district. In each garden 1 soil profile was done, except for the Benedictines garden (2 profiles). Studied soils were characterized by thickness of about 200 cm. The depth of humus horizons in some of them exceeded 100 cm. All soils were classified as Hortic Anthrosols [WRB 2015].

In each distinguished horizon or layer in the soil profile disturbed and undisturbed samples (in metal cylinders of 100 cm^3 volume, in minimum 3 replicates) were taken. The following physical soil properties were performed: texture by the PN-R-04032 [1998] method, density of soil particles by pycnometer and bulk density [Blake, Hartge 1986]. The soil water retention curves (pF) were determined using pressure plates [Soil Moisture Equipment Corp., Santa Barbara CA, USA] according to Richards method [Klute and Dirksen, 1986]. The potential in the range from 0.1 to 3.4 pF was measured in soil samples with undisturbed structure and at pF 4.2 in the disturbed soil [Klute 1986]. The pF models were fitted to the experimental water retention data using Van Genuchten model [1980]. Based on pF curves, the following parameters were calculated: maximum water content, drainage porosity, water field capacity (WFC = pF 2.0), permanent wilting point (PWP = pF 4.2) and plant available water content (PAW) was calculated by the following equation: PAW = WFC - WP.

In the studied soils the largest share had a sand fraction (2-0.5 mm) with a predominance of 0.5-0.25 mm and 0.25-0.01 mm subfractions. Majority of horizons or layers were characterized by a sandy loam and loam texture in upper horizons and sand texture in bottom ones. The density of soil particles was the lowest in horizons with a high organic matter content and increased in bottom horizons. Studied soils were characterized by a greater diversity of bulk density, amounting to 1.17-1.68 $Mg \cdot m^{-3}$, than the density of soil particles. Generally, surface horizons were poorly compacted. The maximum water content value reached 0.53 $m^3 \cdot m^{-3}$. It was greater in the surface and subsurface horizons and changed irregularly in the deeper horizons. Water field capacity varied in wide limits (from 0.07 to 0.43 $m^3 \cdot m^{-3}$) being always the highest in surface horizons. Whereas sandy, bottom horizons had the lowest permanent wilting point (0.02-0.03 $m^3 \cdot m^{-3}$) and surface horizons differed from them much more. Surface horizons distinguished higher plant available water content, with the maximum value of 0.28 $m^3 \cdot m^{-3}$, than deeper horizons or layers.

Geological laboratory capacities for rock and soil physical-mechanical investigation

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Keywords: laboratory, test, particle size, physical - mechanical parameters, determination, soil, water, chemical composition.

The Lithuanian Geological Survey (LGT) Laboratory performs the main laboratory tests:

- lithological rock and soil investigation and testing;
- rock and soil physical - mechanical parameters investigation and testing;
- water, rocks and soil chemical composition determination.

All laboratory tests are carrying out according to ISO standards and LST Lithuanian standards and LAND based normative documents.

Today, the Laboratory of the LGT is within the capacity to perform the following tasks:

- Determination of water content;
- Determination of density (rock and soil);
- Determination of particle density (Pycnometer method);
- Determination of particle size distribution (sieving method);
- Determination of particle size distribution (sieving, pipette and laser difraction) method;
- Oedometer test;
- Compression test;
- Direct shear test;
- Determination of Atterberg limits;
- Determination of organic matter content and LOI (loss on ignition);
- Carbonate content determination;
- Rocks, soils and water chemical composition determination.

For the evaluation of the soil particle size: the laser diffraction particle size determination unit “Analysette 22” MicroTec plus with Wet Dispertion Unit is used for more accurate determining of clay and silt soil particles. Measuring range is between 0.08 -2000 ɥm.

Direct shear tests are used in earthworks and foundation engineering for the determination of effective shear strength of soils. Angle of friction and cohesion determined from effective stresses. Direct shear tests are carried out with modern semi-automatic devices.

An oedometer tests measure soil's consolidation properties. Oedometer tests are performed by applying different loads to a soil sample and measuring the deformation response. The results from these tests are used to predict how a soil in the field will deform in response to a change in effective stress. The main parameters derived from the oedometer test relate to the compressibility and rate of primary consolidation of the soil. The main parameters which can be derived from the oedometer tests are carried out on undisturbed samples: 1) compressibility parameters E_{oed}; 2) coefficient of consolidation c_v.

Rocks and hard soils compression test. The main parameters which can be derived from the compression test carried out on undisturbed samples are:

1) qu unconfined compresisve strength;
2) cu udrained shear strength.

In co-operation with the Department of Hydrogeology of the Lithuanian Geological Survey, the Laboratory is participating in soil state and groundwater state monitoring. Water and soil tests were conducted. Loss of ignition, insoluble residue and oxides (Al_2O_3, Fe_2O_3, CaO, MgO), organic matter content and ash were determinated in soil samples and main anions, cations (Cl, SO_4, HCO_3, NO_2, NO_3, Na, K, Ca, Mg, NH_4) and reaction (pH_{H2O} , pH_{KCl}) of water composition were determinated.

The laboratory is investigating groundwater and rocks chemical composition. Every year laboratory is taking part in groundwater state monitoring program where the main anions and cations of water composition are determinated (Cl, SO_4, HCO_3, NO_2, NO_3, Na, K, Ca, Mg, NH_4).

Now is **on service** of LGT and other national projects:

State soil monitoring of arable soils (grain size, LOI, pH determination, sample preparation for chemical analyses: sieving, homogenization, milling);

State ground water monitoring.

Development of integrated geophysical/geochemical methods of soil and groundwater pollution assessment and control in problematic areas (IMPACT)

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Rational use and management of soil and water resources requires application of efficient monitoring system for identification of areas at risk and for undertaking timely preventive or remediation actions. At present, mapping of soil pollution status is based entirely on geochemical methods. Usually there is no satisfactory information on the extent and range of cumulative retrospective pollution in the area. This results in the need of a large number of samples to be collected from the studied area, and of expensive and time- consuming chemical analyses. Among anthropogenic soil pollutants, trace elements (Potentially Toxic Elements – PTEs) are the most problematic, widespread and persistent group of pollutants that have accumulated in soil since the beginning of industrial revolution.

The optimized two-stage monitoring techniques based on integrated geophysical-geochemical methods has been proposed for assessment of soil quality with respect to trace element pollution. The investigation was carried out in 9 pilot sites located in Poland and Norway. Some of them consisted of 3 sub-sites (e.g. each of different land use or in different distance from pollution source). Studied sites differed with respect to pollution level, geological background, land use as well as their magnitudes. At the first stage, fast, simple and cost-effective on-site magnetic screening method based on surface magnetic susceptibility measurements and analysis of vertical distribution of magnetic susceptibility in 30 cm deep topsoil cores was applied. Magnetic susceptibility is a worldwide used measure of (ferri)magnetic minerals occurring in soils, sediments and dusts. In soils, these minerals are of various origin: air-derived particulate pollutions, parent rocks or pedogenesis. Human activity causes different changes in the content of magnetic minerals as well as their spatial and vertical distribution in soil profiles. On the basis of these measurements magnetic proxy maps were generated delineating the local magnetic "hot spots" with high probability of increased pollution level, since magnetic minerals are characterized by an affinity for other elements occurring in the soil. At the second stage, on the basis of the magnetic pre-screening, a relevant dense geochemical monitoring network was applied in the areas of identified elevated risk of pollution with PTEs. Such solution significantly reduces the required number of samples and chemical analyses, and consequently costs of the environmental impact assessment and increase its spatial resolution. The study proved the integrated two-stage geophysical-geochemical method to be a feasible, reliable and cost-effective tool for identification the extent of soil pollution and areas at risk.

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Crop, water, soil under changing climate – evidence from long term experiments

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Key words: soil, drainage water, cereal crops, biomass, modelling, climate change.

Valinava long-term experiment (55.22° N, 23.51° E) established in 1991 at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry and is managed by the staff of the Department of Plant Nutrition and Agroecology. The experiment is situated on the terrace of the Dotnuvele River and occupies 4.4 ha. Prevailing soil is sandy loam and light loam *Endocalcari – Endohypogleyic Cambisol* (*CMg-p-w-can*). Carbonates depth is 40–60 cm. Soil pH_{KCl} – 7.2, content of total N – 0.18 %; available phosphorus (P_{AL}) – 66 mg kg^{-1}, available potassium (K_{AL}) – 99 mg kg^{-1}. Crops are grown in 4-course crop rotation: spring barley (*Hordeum vulgare* L.), red clover (*Trifolium pratense, L.),* winter wheat (*Triticum aestivum, L.*) and spring oilseed rape (*Brassica napus, L.*). Crops are grown under three levels of management intensity: a) conventional, b) integrated and c) organic, each replicated twice in space, occupies approximately 786 m^2 (32.2 m long, and 24.4 wide) and contains 6 sub-plots (44 m^2 – 20 m long, 2.2 m wide).

Cereals in conventional and integrated agroecosystems were applied with herbicides, fungicides and insecticides and in organic system were grown without application of industrial fertilisers and plant protection measures. In conventional system, winter wheat grown for a target yield of 6 – 7 t ha^{-1}, and spring barley for 5 t ha^{-1}.

In this experiment measuring of drainage water runoff amount, ground water table levels, and crop yield and biomass production are performed. For soil moisture monitoring sensors – irrometers ‘Watermarkt’ are used. Experimental area includes plots with perennial grasses thus providing possibility to observe the changes in plant species.

For indication of nitrogen and water deficit in cereal crops simulation with model DSSAT v4.0.2.0 is performed. These studies showed that water stress simulated by the DSSAT v4.0.2.0 model correlated relatively well with actual readings of irrometers. The correlation coefficient of three years data in spring barley was 0.85, $p<0.05$, and in winter wheat – $r = 0.80$, $p<0.05$.

This model is also was used to simulate the changes of productivity of cereal crops under various scenarios of climate change. Simulation of spring barley and winter wheat grain yield as affected by climate change was performed according to scenarios, with different levels of average air temperature, CO_2 concentration and sum of precipitation during growth period. No extreme events were planned and currently applied crop growing technologies were used, including dates of sowing, varieties, etc. For this reason results of simulations can be treated as very preliminary estimations of possible effects on grain yield caused by changing climate. Simulation showed that spring barley can be affected by climate change more negatively than winter wheat. Many studies were aimed to examine the likely impacts of climate change on cereal crops productivity. However, it is still unclear if a range of conventional adaptive measures, such as changing of sowing time or varieties, can be effective in order to completely adapt spring barley and winter wheat to new climate conditions.

Soil water dynamics during precipitation in genetic horizons of Albeluvisols

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Albeluvisols derived from silty deposits dominate in the soil cover of the Carpathian Foothills. The profile of these soils varies depending on relief; gradient, shape and length of slope; and land-use pattern. Arable land covers a much larger area than woodland. Woody areas and flat sections of arable land have soils with the following genetic and diagnostic horizons: luvic, fragic, argic and glossic. The hydrophysical properties of soils derived from silty deposits in the Polish part of the Carpathian Mts. are determined by the grain-size distribution of the parent material and the soil's properties shaped in the deposition process the soil-forming processes, such as lessivage and the morphogenetic processes that presently shape the relief. These factors are responsible for the differentiation of hydrophysical properties across the soil profile. These properties of soils (the rates of water retention, filtration and infiltration, and the moisture distribution over the soil profile) determine their ability to take in rainfall, the amount of rainwater taken in, and the ways of its redistribution.

The humic horizon and the eluvial (luvic) horizon of Albeluvisols have higher total porosity, drainage porosity, available water retention, and saturated hydraulic conductivity (Ks) than the illuvial (argic and fragic) or parent material horizons. On the other hand, bulk density, clay fraction content, and retention of water unavailable for plants are lower in the eluvial horizons than the illuvial ones. While the humic and eluvial horizons show greater potential for water filtration, it is the illuvial and parent material horizons that determine the filtration capacity of the entire soil. The latter horizons both have a very low saturated hydraulic conductivity (Ks), which makes it nearly impossible for groundwater to supply these layers. Tongues – glossic forms found in Albeluvisols – exhibit a higher filtration capacity and thus help supply deeper soil horizons.

Due to these conditions the aim of the study was to investigate the dynamics of soil moisture in genetic horizon in Albeluvisol during 2015 year. The second aim was to recognize how fast and how depth water from precipitation gets to soil horizons?

This study was conducted in Lazy (situated on the northern edge of the Carpathian Foothills, lies just 40 km east of Cracow) near Kraków.

The soil was located on the north slope with an inclination 5-8. Soil water content was measured by 5TM Moisture and temperature sensor and collected by logger Em50 (Decagon Devices USA). Data were captured during 2015year every 10 minutes from 6 sensors - 10 cm, 20 cm, 40 cm, 60 cm and 80 cm depths. Precipitation data comes from meteorological station situated 50 m close to soil profile. This Station belongs to Field Research Centre in Lazy is part of the Jagiellonian University's Institute of Geography.

The investigated soil represents very common soil type – Albeluvisol, existed in the Carpathian Mts. derived from silty parent material – sometime described as loess-like deposit. Soil has typical arrangment of genetic horizons: humic, eluvial, illuvial and parent material. This soil has loamy silt texture in all genetic horizons, 11,1 $g \cdot kg^{-1}$ organic matter up to 20 cm depth. Soil characterises by different bulk density 1.49−1.72 $Mg \cdot dm^{-3}$. The ranges of chosen physical properties of this soil are: total porosity 0.45−0.36, water field capacity 0.33−0.31 $m^3 \cdot m^{-3}$ and hydraulic conductivity in saturated zone Ks 6.732−0.002 m·day.

Two zones differing in the type of water regime were distinguished in Albeluvisols: an upper zone (approximately 0-50 cm) comprising humic and eluvial horizons, and a lower zone (approximately >60 cm) consisting of illuvial and parent material horizons. The upper zone shows lower moisture content, and relatively wide fluctuations in moisture content, compared to the other zone. The lower zone has stable moisture content during the vegetation season, with values around the water field capacity.

During the 2015 year 173 numbers of days with precipitations took place. It was very differential. The highest rainfall had 39.4 mm, mean 3.71 mm, median 1.50 mm and standard deviation 6.02 mm.

Large changes in soil moisture were observed while rainfall. These changes depend on the volume of the precipitation and soil moisture before precipitation. The following changes of moisture in the soil profile during precipitation were distinguished:

If soil moisture in upper zone horizons oscillates around field capacity (hight than 0.25-0.30 $m^3 \cdot m^{-3}$) in the lower zone horizons there is an evident increase in soil moisture,

. If soil moisture in the upper zone horizons is much lower than the field capacity (less than 0.20 $m^3 \cdot m^{-3}$) the soil moisture in the lower zone has very little fluctuates.

Wetting front moves in the soil profile at different rates, approximately 10 minutes per 10 cm depth.

The range of wetting front in the soil profile depends on the volume of the precipitation and soil moisture. The heavier precipitation, the wetting front in soil profile reaches deeper horizones. The wetter the soil is, the faster soil moisture in the deeper genetic horizones increase.

Functional and Structural Succession of Soil Microbial Communities in Plugged and Naturally Developed Soils

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Soil microbial community is in a complex, under the dynamic in differently managed and naturally developed ecosystems. Studying soil microbial community structure and determining the development of represented microbial biodiversity, nutrient cycling, responds of natural and anthropogenic disturbances and land-use changes could be possibly indicated even by plant ecosystematics, soil nutrient cycling quality and soil productivity. It was valued, that soil management significantly alters soil characteristics, including physical, chemical, and biological properties. This fact is particularly relevant, where unsuitable land management together with climatic constraints can contribute to increased rates of erosion and other degradation processes. This can lead to a loss in soil fertility and a reduction in the abundance and diversity of soil microorganisms. The changes in soil microorganisms and soil microbial processes is under the changes of the quantity and quality of plant residues entering the soil and their distribution, through changes in nutrients and biomass inputs. However, the intensive use of pesticides can drastically modify the function and structure of soil microbial communities, thereby altering the normal functioning of terrestrial ecosystems within the term of soil quality. Disturbed and naturally developed soils have specific soil microbiota, and the extensive soil management may effect to increase in microbial biomass. Soils under the tillage can be more sensitive to reduction in soil microbiota due to desiccation, mechanical destruction, soil compaction, reduce pore volume. Some organic fertilizers promote the activity of soil microbial communities.

While there are many studies of the dynamics of such functional, biochemical and microbial parameters in soil, including the impacts of management, most studies have taken the parameters in isolation, and widely contrasting timescales in studies using different indicators makes comparisons between studies difficult. Additionally, many of the studies using such indicators have been made across different soil types, soil that has been under contrasting long-term management, or different habitats. Less is known about the relative value of such indicators for differentiating areas under different management on the same soil type, or for providing information on changes to soil quality in the short-term. The aim of the present functional and structural succession studies it was relevant to find out the relative value of functional, biochemical and microbial parameters measuring soil quality estimating (a) the effects of different management practices, and (b) the relationship between soil physicochemical and biochemical properties and the microbial community structure.

Potential of visible and near-infrared spectroscopy as a rapid tool to determine several soil properties at different scales: from the field to a Polish spectral database.

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This paper evaluates the use of visible and near-infrared (VIS-NIR) spectroscopy as a fast, cheap and reliable method to determine physical and chemical soil properties. Successful attempts at simultaneously predicting several soil properties at different scales are reviewed.

At the field or farm scale VIS-NIR spectroscopy is a practical tool for mapping using an "on-the-go" sensor or a classical VIS-NIR spectrometer. The precision of the method in certain conditions is similar to that of classical "wet chemistry" methods for e.g. SOC and N content and soil texture determination. This can prove to be of major interest for precision agriculture. Moreover, at field scale the advantage of "on-the-go" sensors is the possibility to further reduce the number of calibration samples that need to be analysed in the laboratory to less than 1/ha to obtain highly detailed maps of soil properties (Debaene et al., 2013).

There is a growing demand for high-resolution soil data to cover large regions on the one hand and a lack of such data on the other hand (Grunwald et al., 2011). Local libraries are not suitable for predicting samples of a larger region due to the immense soil spatial variability. Therefore, at a regional or national scale, the diversity of soils demands from us to build large soil spectral libraries and to develop chemometric tools to improve the prediction robustness. To that aim, a spectral library (nation-wide) of Polish mineral soils has been built (with sections still under construction) at IUNG-PIB Puławy. More than 2500 samples have already been scanned and incorporated into the spectral library. The combination of the soil spectral data with the physical and chemical data of the samples allowed to build prediction models of many soil properties. The lowest prediction accuracy of large scale models is due to the poor representation of the soil diversity in spectral libraries.

The conclusion is that if provided a suitable soil spectral database is built, from field to national scale by using laboratory, in-situ or "on-the-go" methods, VIS-NIR spectroscopy becomes a method of choice for the prediction of several soil properties.

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Spatial variation of selected physical properties of soils derived from loess

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The aim of the study was the assessment of spatial variation of chosen soil properties on farmland plot that soil cover consists of chernozems mainly. The research was caused by at explanation attempt of the origin of, visible in satellite imaginary, irregular darker and lighter patches of topsoil.

One hundred forty eight soil samples were collected in net of 50 m x 50 m grid. Soil samples were taken from a depth of 0-25 cm using Egner sampler. Color was determined based on Soil Color Munsell Chart in moist soil material. Dried and sieved soil was used in order to analyze soil texture according to method of Bouyoucos as modified by Casagrande and Prószyński. Loess index was calculated based on silt and sand content. A horizon Darkness Index based on moist soil color chroma and value was determined. Results were elaborated statistically and geostatistically. Normal distribution probability was determined based on Shapiro-Wilk test. Moran's global and local indices were calculated in order to analyze spatial variation of studied parameters using GeoDa software.

Silt clay texture predominated within soil sampled. Sand was most variable within soil fractions and showed moderate variability. Silt and clay variability was classified as low. Fractions content did not follow a normal distribution. Loess index (Ls) showed a high variability on studied loess area, what is connected with a high variability of coarse silt to sand fraction content ratio. Sand and clay content showed a significant Moran's global autocorrelation index, what proofs occurrence of clusters with high and low values of these fractions. Contour maps revealed a higher content of silt and clay in more elevated parts of studied areas, and sand was more present in lower position.

Very dark brown (10YR 2/3), very dark greyish brown (10YR 3/2) and dark brown (10YR 3/3) soil color predominated within moist topsoil samples. Moreover, soil color was used to distinguish mollic from chernic horizon. On studied area predominated chernic horizon over mollic,what is an expression of chernozems predominated occurrence, and, to a lesser extent, phaeozems. A horizon Darkness Index was highly differentiated and did not follow a normal distribution.

On the base of color and texture studies, we can assume that present soil cover of studied area is an effect of loess soils evolution and erosion process. Earlier microrelief and soil differentiation was altered due to longtime soil tillage. An expression of primary soil cover and pedogenesis is current differentiation of soil color, mainly.

The representativeness of soil spectra obtained by proximal sensing measurements in estimation of soil properties

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In recent years remote sensing techniques are used increasingly more for obtaining data about various soil properties. Such techniques could replace or support traditional laboratory analysis. These methods for the rapid, relatively inexpensive, safe, and noninvasive estimation of the properties of soils in field and laboratory conditions are numerous. Visible and near infrared spectroscopy (VNIRS) allows quick acquisition of quantitative information about a number of soil parameters based on a single high-resolution spectrum, usually in the range of 350–2500 nm.

Sensors recording radiation reflected from the analyzed surface can be installed on different platforms. Reflectance measurements are performed increasingly often from ground level, utilising on-the-go or proximal sensing methods, wherein sensor is no higher than 2 meters above the ground. However proximal sensing method has some difficulties, which are related with keeping the proper size of viewing area. Consequently, concept of representative elementary area (REA) was developed, where REA is defined as the minimum area of a surface required from which a given soil parameter measurement becomes independent of the size of the sample area. Research conducted in laboratory condition on five different soils, using three illumination angels and two different views allowed to determine the criteria when proximal sensed spectra is representative.

To obtain correct measurement results, sensor should be high enough to be looking at REA. Height of a sensor is described as a ratio between diameter of field of view to the HSD index, which expresses the standard deviation of the height of a soil surface area within its delineated basic digital elevation model unit. The higher HSD correspond to the greater irregularities of the soil surface shape). Diameter of REA was around 60 times of HSD.

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Hydrophysical properties of artcic soils developed on micro-relief forms

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The water retention characteristics as well as basic physical parametres and water conductivity of the arctic zone soils were determined.

Soils were classified as Turbic Cryosol (Skeletic), Turbic Cryosol (Siltic, Skeletic) and Brunic Turbic Cryosol (Arenic). They developed on different micro-relief forms, specific for the region - mud boils, cell forms, sorted circles and tundra polygons.

Water retention curves were similar in their course for the mud boils, cell forms, and sorter circles ie for TurbicCryosols. For these forms, the mud boils showed the highest water retention ability, whereas the sorter circles – the lowest one. Water retention curves for the tundra polygons (Brunic TurbicCryosol, Arenic) were substantially different from these mentioned above. For the high soil water potentials (higher than -7 kJ m-3), they retained a considerably larger amount of water whereas for the potential lower than -7 – -16 kJ m-3, their ability for water retention rapidly decreased and it was lower than that for the cell forms. The tundra polygons were characterized by the lowest bulk density of 1.26 g cm-3, whereas the sorter circles (Turbic Cryosol, Skeletic) – the highest: 1.88 g cm-3. Total porosity was the highest for the tundra polygons (52.4 and 55.5%) and the lowest – for the sorted circles (28.8 and 26.2%).

Pore size distribution of the investigated soils showed that independently of depths, the highest content of large and medium pores was noticed for the tundra polygons, i.e. 21.2-24.2 and 19.9-18.7%, respectively. The lowest content of large pores was observed for the cell forms (6.4-5.9%) whereas the mud boils exhibited the lowest amount of medium sized pores (12.2-10.4%) (both Turbic Cryosols Siltic, Skeletic). The highest content of small pores was detected in the mud boils – 20.4 and 19.0%.

The greatest water conductivity at the 0-5 cm depth for the higher values of water potentials (> -7 kJ m-3) was shown by tundra polygons (Brunic-Turbic Cryosol, Arenic) – 904-0.09 cm day-1, whereas the lowest were exhibited by Turbic Cryosols – 95-0.05 cm day-1. Between -16 and -100 kJ m-3, the water conductivity for tundra polygons rapidly decreased to 0.0001 cm day-1, whereas their decrease for the other forms was much lower and in consequence the values were 0.007, 0.04, and 0.01 cm day-1 for the mud boils (Turbic Cryosol (Siltic, Skeletic)), cell forms (Turbic Cryosol (Siltic, Skeletic)), and sorted circles (Turbic Cryosol (Skeletic)), respectively. In the 10-15 cm layer, the shape of water conductivity curves for the higher values of water potentials is nearly the same as for the upper layer. Similarly, the water conductivity is the highest – 0.2 cm day-1 for tundra polygons. For the lower water potentials, the differences in water conductivity increase to the decrease of soil water potential. At the lowest potential the water conductivity is the highest for sorted circles – 0.02 cm day-1 and the lowest in tundra polygons – 0.00002 cm day-1.

References

Results of the investigations were published in:

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