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Reducing the risk of negative climate change impacts in the landscape

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SLOVAK UNIVERSITY OF AGRICULTURE IN NITRA
Faculty of Horticulture and Landscape Engineering

UNIVERSITY OF AGRICULTURE IN KRAKOW
Faculty of Environmental Engineering and Land Surveying



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Slovak University of Agriculture in Nitra

prof. Ing. Dušan Igaz, PhD.

and

dean Faculty of Environmental Engineering and Land Surveying,
University of Agriculture in Krakow
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25th edition of the International scientific conference ENVIRO 2021 set its goal to apprise the participants and scientists and professionals of the achievements of involved institutions in following fields:

- New trends and practice in environmental education
- Climate change impacts, adaptation and mitigation
- Effect of water management protection structures on landscape protection from drought and floods
- Outlook and perspectives of landscape conservation and design
- Biological, ecological, agricultural and technical measures in land consolidation in relation to climate change
- Use of geo-information technology applications in the landscape
- Modern approaches for designing and maintaining urban spaces

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CONTENT of ABSTRACTS

Global climate change and natural changes of climate, possible regional consequences and necessary measures Milan LAPIN	9
Hydrology in the time of the Great Challenge: How to manage changing conditions, what and how to measure, observe, simulate and predict Michal HAZLINGER.....	10
SECTION New trends and practices in environmental education	11
The hidden world of Žitný ostrov- practical EVV programs in SEV SAŽP Dropie Katarína VAJLIKOVÁ, Lilla SZABÓOVÁ	12
Biodiversity oriented premises and their multiple benefits ¹ Štefan JANČO, ² Slavomíra VOGELOVÁ	13
Practical courses in the landscape engineering study programme Andrej TÁRNÍK, Elena AYDIN, Vladimír KIŠŠ.....	14
Creation and implementation of environmental monitoring course in higher education Tatiana KALETOVÁ	15
Environmental amateur course Mária ŠUGAREKOVÁ, Martina ZELEŇÁKOVÁ.....	16
International projects as a driver for introduction of new practice in educational process Kateryna UTKINA, Ganna TITENKO.....	17
SECTION Climate change impacts, adaptation and mitigation	18
Food production and the call to mitigate the effects of climate change Elena AYDIN, Deniz AYDIN	19
Shelterbelt systems as a means of mitigating the negative effects of climate change on agricultural landscapes Svitlana SYDORENKO ¹ , Hryhorii HLADUN ² , Serhii SYDORENKO ¹	20
Water retention specification in the landscape to mitigate the possible effects of the global climate change Beáta NOVOTNÁ, Vladimír KIŠŠ, Lucia TÁTOŠOVÁ, Ľuboš JURÍK	21
Climate change impact assessment and nature-based mitigation options in flood vulnerable landscapes in Greece Eleni-Ioanna KOUTSOVILI ¹ , Ourania TZORAKI ¹ , Nicolaos THEODOSSIOU ² , Petros GAGANIS ³	22
Impact of climate change on Georgia's Agriculture sector Lia MEGRELIDZE, Nato KUTALADZE, Gizo GOGICHAISHVILI.....	23
Forest fire risks in Ukraine in the context of climate change Serhii SYDORENKO, Volodymyr VORON, Svitlana SYDORENKO, Iryna KOVAL, Yevhen MELNYK	24
Potential of Remote Sensing in Landscape and Urban Water Management Planning Lucia TÁTOŠOVÁ - Beáta NOVOTNÁ – Dušan HÚSKA – Gabriela TURŇOVÁ	25
Carbon dioxide and land use contribution to climate change Viliam NOVÁK.....	26
Nutrient leaching from top layer of arable sod-podzolic sandy loam soil amended with fertilizer and biochar Tatiana ABRAMOVA, Natalya BUCHKINA	27
Multiyear effect biochar application on soil N₂O emission, soil properties and crop yields in Haplic Luvisol Ján HORÁK, Elena AYDIN, Dušan, IGAZ, Tatijana KOTUŠ, Lucia TOKOVÁ	28
Effect of Biochar application on CO₂ Emissions from Haplic Luvisol with or without N-fertilizer Tatijana KOTUŠ, Ján HORÁK.....	29

Effect of biochar application and re-application on the soil water content of agriculturally used soil Lucia TOKOVÁ, Dušan IGAZ, Elena AYDIN	30
Treatment of methylene blue contaminated wastewater by biomass not exposed to industrial wastewater Gayatri BHOI, Priyanka PRUSTY, Somya P. SAHANI, Subrat KUMAR MALICK, Ankita MOHANTY, Anupriya SINGH	31
Vplyv rôznej úrovne caespestechniky na rozvoj koreňového systému trávnik Martin MEDZANSKÝ	32
Radial growth measurements and rainfall impact during budbreak period of Royal walnut (<i>Juglans regia</i> L. var. <i>Chandler</i>) in 2019 Martina KOVÁČOVÁ, Viliam BÁREK.....	33
Evaluation of meteorological and hydrological conditions in the Nitra river basin in 2020 Vladimír KIŠŠ, Andrej TÁRNÍK, Ján ČIMO	34
Degradation of glaciers of basin of the river Pirikiti Alazani (Georgia) due to climate change ¹ George KORDZAKHIA, ¹ Larisa SHENGELIA, ² Genadi TVAURI, ³ Murman DZADZAMIA	35
Assessing soils vulnerability to agricultural drought: a Belarusian Polesye case study Valentin YATSUKHNO	36
SECTION Biological, ecological, agricultural and technical measures in land consolidation in relation to climate change	37
The influence of climate on the occurrence of forest and landscape fires in the left-bank forest steppe of Ukraine Yevhen MELNYK, Vladimir VORON, Iryna KOVAL, Serhii SYDORENKO	38
The influence of biochar on agricultural soils in the south of the Far East of Russia Olga NESTEROVA ¹ , Viktoriia SEMAL ^{1,2} , Marya BOVSUN ¹ , Ivan VASENEV ⁵ , Anastasia BRIKMANS, Tatyana KARPENKO ^{1,4} , and Nikolay SAKARA ³	39
Influence of climate change on the radial growth of Scots pine (<i>Pinus sylvestris</i> L.) in the Forest-Steppe, Ukraine Iryna KOVAL.....	40
Spectral manifestations of the plant growth depending on the applied compost amount Lucia TÁTOŠOVÁ, Anna Báreková, Martina DEMOVIČOVÁ, Mária SIRÁŇOVÁ	41
SECTION Effect of water management protection structures on landscape protection from drought and floods	42
Blue-green infrastructure in a landscape adapting to current climatic conditions ¹ Jozefína POKRÝVKOVÁ, ² Richard HANZLÍK, ² Ľuboš JURÍK, ³ Karakoz NARBAYEVA, ³ Anvar GAPPAROV, ² Peter LUKÁČ,	43
Green roofs for cities surface runoff regulation Svitlana BURCHENKO	44
Change of flow in drainage channels by reverse water flow from a recipient ¹ Richard HANZLÍK, ¹ Ľuboš JURÍK, ² Jozefína POKRÝVKOVÁ, ³ Karakoz NARBAYEVA, ¹ Peter LUKÁČ	45
Ecohydrological status of three intermitten flow Mediterranean rivers of Cyprus, Slovenia and Greece ¹ Stamatia PAPASARAFIANOU, ¹ Theodoros CHATZIVASILEIOU, ¹ Eleni-Ioanna KOUTSOVILI, ² Simon RUSJAN, ¹ Ilias SIARKOS, ¹ Ourania TZORAKI	46
Influence of Sand Particle Size on Liquid Limit of Sand Bentonite Mix ¹ Sanjeet SAHOO, ² Sagarika Priyadarshani DASH, ² Hamza AHMAD KHAN, ^{3,4} Janarul SHAIKH	47
SECTION Outlook and perspectives of landscape conservation and design	48
Directions of ecological reconstruction of cities' green infrastructure Olena GOLOLOBOVA.....	49
Analysis of the interconnection of trees and sacral buildings of the Romanesque period Denis BECHERA, Gabriel KUCZMAN, Roberta ŠTEPÁNKOVÁ, Miroslav ČIBIK	50

Accompanying greenery of roads in selected localities of vineyard areas of western Slovakia Denis BECHERA, Gabriel KUCZMAN, Martina VEREŠOVÁ, Miroslav ČIBIK.....	51
Vineyard cultural landscape renewal options through landscape-architectural solutions Martina VEREŠOVÁ, Miroslav ČIBIK, Lucia ŠURINOVÁ	52
The role of local spatial development plans of Uście Gorlickie community in the protection of the South-Lesser Poland Protected Landscape Area Agnieszka Maria GERTNER, Renata GIEDYCH.....	53
Plastisphere – landscapes ^{1,2} Agnieszka DĄBROWSKA.....	54
Analysis of the usability of sewage sludge for application in agricultural landscapes ¹ Peter LUKÁČ, ¹ Ľuboš JURÍK, ¹ Richard HANZLÍK, ² Jozefína POKRÝVKOVÁ.....	55
SECTION Modern approaches for designing and maintaining urban spaces	56
The blue-green urban infrastructure as the way to mitigate the negative effects of climate change ^{1,2} Žaneta TUCHOWSKA, ¹ Barbara BORAWSKA-JARMUŁOWICZ, ² Piotr DĄBROWSKI.....	57
Street models with green and blue infrastructure as a tool in planning a city resilient to climate change Justyna RUBASZEK, Elżbieta SZOPIŃSKA.....	58
The green streets application in limited urban space as an element of ecological connectivity system ¹ Joanna ORZIŃSKA, ² Agata CIESZEWSKA	59
The Experience of Using Parklets in Ukraine to Improve Public Urban Space ¹ Kateryna ZHYKHAREVA, ¹ Sergii ROGOVSKII, ¹ Alla MARCHENKO, ² Roman ZHYKHAREV	60
University campus – Sustainable multifunctional component of the city urbanized area Miroslav ČIBIK, Roberta ŠTĚPÁNKOVÁ, Denis BECHERA, Gabriel KUCZMAN	61
SECTION Use of geo-information technology applications in the landscape	62
Using GIS technologies to assess the risk of erosion processes in landscapes in the context of climate change <i>Nadiya MAKSYMENKO</i>	63
Landscape memory – application of program ArcGIS for mapping human activities Vendula MORAVCOVA, Jana MORAVCOVA, Petra KOSOVA.....	64

Global climate change and natural changes of climate, possible regional consequences and necessary measures

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Total climate changes are a combination of climate change due to human activities and climate changes of natural origin. Further development of climate change can be predicted, if we know the future development of greenhouse gases (GHG) emission into the atmosphere and other human interventions with the world climate system. The future development in natural climate changes cannot be reliably predicted. It is very probable that climate change caused by humans will be much more significant than the natural climate changes, already from 2020. It is almost certain that the concentration of GHG in the Earth's atmosphere will rise further for at least 100 years. The climate change scenarios can be prepared, according to the outputs of General Earth's atmospheric circulation physical models (GCM). Adapting and mitigation measures projection to utilize or slow down the impact of the expected climate change are the next steps of the climate change issues solving. A rise of mean annual temperature by 2°C and no significant changes in annual precipitation totals was observed in Central Europe since 1980. Global mankind, individual countries, cities, institutions, companies and individuals can react in three following ways to ongoing and expected climate changes: 1) They can behave as if it were only natural climate changes and pay no attention on climate change due to human activities; 2) Accept the fact that the climate will change in the extent of scenarios for climate change and prepare adaptation measures at least for middle size scenarios, in important areas for biggest size scenarios of climate change on national, enterprise and local level; 3) Understand that it is necessary to take mitigation measures as well, to slow down the climate change by reduction of GHG emission and improvement of country management, whereby such measures have to be based on treaties on global level; in coordination with mitigation measures also the adaptation measures to reduce the negative and utilize the positive impacts of climate change need to be prepared. It is obvious that the highest priority belongs to the measures connected with more frequent appearance of drought and storm rainfall as in the past. Slovakia still belongs to countries with low efficiency of energy use and small share of renewable energy resources on the total energetic mixture, whereby this brings another possibility to reduce human interventions with the world's climate system.

Key words: *climate change, impacts, adaptation and mitigation, natural climate changes*

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Hydrology in the time of the Great Challenge: How to manage changing conditions, what and how to measure, observe, simulate and predict

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Slovakia is the flood prone area. We have many information about flooding from historical archives since the 13th century. But floods are not historical phenomena, heavy flood events were observed in this century (2002, 2010, 2013) too. Due to the Slovak position „on the roof of Europe“, we have many floods, which are not „imported from abroad“, but are the result of rainfall – runoff activities in our own territory. Therefor the good meteorological and hydrological monitoring and forecasting service is a necessity. First steps for establishment of regular hydrological monitoring are from 19th century. But the expanse of the hydrological (and meteorological) measuring sites occurred in the 20th century. The number of water level stations increased from 38 (in 1914) to 400+ (in 1980). But the real (r)evolution happened in the beginning of 21st century. Two phases of POVAPSYS project changed the hydrological monitoring from manual to automatic and from periodic measurement transmitted via telephones to real time measurement. Hydrological forecasting changed too. From simple methods based on empirical regression and simple outflow wave transformation, to the network of hydrological models. HEC-HMS and HBV rainfall – runoff models are used for predicting of discharge and water level in 120 profiles in all relevant watersheds in Slovakia. Deterministic and Ensemble forecast of ALADIN and ECMWF models were used as precipitation input, so the hydrologist has 100+ scenarios to consider. Flash flood forecasting module based on the exceeding of threshold potential of country is available too. All model outputs, as well as many other modules useful for the daily operation of modern hydrological monitoring and forecasting system are managed within operational system called HYPOS. This system, developed by MicroStep-MIS, is in the daily operation by Slovak Hydrometeorological Institute. But new challenges are approaching. Climate Change will affect all aspects of human being, including operational hydrology. Warmer climate will affect the hydrological cycle. The probability of longer periods of drought, as well as heavy rainy periods, is increasing. Heavy torrential precipitation events will occur more often in summer periods and the intensity and amount of rain will be higher. Hydrological prediction systems, as well as the whole system of flood protection should be prepared for this new situation. Distant measurement of precipitation, especially by meteorological radar, methods of storm cell tracking and precipitation now casting and methods of flash flood forecasting are getting into spotlight. The change is coming. And we must be prepared.

Key words: *hydrological measurement, hydrological modelling, operative forecast, climate change*

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SECTION

New trends and practices in environmental education

The hidden world of Žitný ostrov- practical EVV programs in SEV SAŽP Dropie

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SEV SAŽP Dropie is located and operates at Dolný Žitný ostrov. The center originally served as a rescue station for the great bustard (*Otis tarda*). Since 1992, it has gradually transformed into a center of environmental education. In 2010, the center innovated the program offer and focused on practical environmental education through experience, support for volunteering and community life, networking organizations and individuals, and sharing experiences and examples of good practice. In terms of content, programs focused on agricultural landscape, biodiversity loss and climate change are implemented. At the national level, SAŽP coordinates the working group for the elaboration of the methodology of eco-centers certification in Slovakia, the establishment of the portal on environmental education ewobox.sk and currently implements accredited innovative education for teachers Environmental education and education for sustainable development. Numerous studies in the field of environmental education and training have shown that more knowledge and information does not automatically mean a change in attitudes and behaviour of individuals. In the current climate crisis, changing attitudes and behaviour of individuals is a key aspect. Environmental residency programs and volunteer work have just a positive impact on changing attitudes and environmental literacy. The hidden world of Žitný ostrov program is based on experience. The participants are confronted with the current state of the agricultural landscape that surrounds SEV SAŽP Dropie (95% of the SPA Ostrovné lúky is formed by arable land) and through various activities gradually identify problems in relation to climate change and biodiversity. However, the most important phase of the program is the joint search for and implementation of solutions, various adaptation measures and voluntary activities. In the agricultural landscape of the SPA Ostrovné lúky, together with partners from the Bratislava Regional Conservation Association, the Research Institute of Water Management and the Faculty of Science of Comenius University, we increased the representation of permanent grasslands by 100 ha, expanded bio corridors by 10 km, established 10 km of bio corridors and restored 62 small wetlands. As part of volunteer activities, we most often plant trees with subsequent care for plantings, prune and plant new willows, clean the landscape of illegal dumps and create various habitats for animals. It is a priority for us to provide participants with an experience of volunteering for nature. If you are not a part of the solution, you become a part of the problem.

Key words: *bio corridors, sustainable development*

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Biodiversity oriented premises and their multiple benefits

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In the EU up to 80 % of the area is used for urbanization and transport infrastructure, agricultural and forestry production and industrial areas. The loss of ecosystems and species is not just an environmental problem. Research indicates that human economy and society depend in many ways on nature and ecosystem services. Nature provides valuable raw materials, regulates the climate, water balance and protects from soil erosion – to name just a few examples. Industrial and commercial premises hold an enormous potential in terms of quality of the environment its ecosystem services. The biodiversity-oriented design of business premises (BOP) is an approach to contribute to the protection and strengthening of biodiversity. BOPs are not only beautiful to look at, but also provide valuable habitats for local fauna and flora. In addition, BOPs can become places of relaxation, education and improve the well-being of employees and society. Overall, they can become a part of the green infrastructure of the neighboring area. In the contribution, principles and measures to plan, create and manage BOPs will be presented. Flower meadows, woods, hedges, green roofs, water bodies and various aids helping small animals are some of the most common measures used in BOP design. Some design elements also improve the well-being, creativity and productivity of employees, guests and neighbors. There are business premises that are even used for environmental education, whether of school pupils or adult visitors. Thanks to the EÚ LIFE BooGI-BOP (*Boosting Urban Green Infrastructure through Biodiversity-Oriented Design of Business Premises*) project, concrete examples of implemented measures, but also interesting examples of the BOP premises from Germany, Switzerland, Austria, France and Slovakia will be presented. Some of them are pioneering solutions. Despite the difficulties encountered in their development, they have been solved with ingenuity and bravely mastered.

Key words: *biodiversity, business premises, environmental quality, climate change*

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Practical courses in the landscape engineering study programme

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The landscape engineering study programme is focused on knowledge of all natural elements like soil, water, climate or atmosphere and their interactions. Students obtain theoretical and practical knowledge for future jobs in the areas such as water management, soil protection and reclamation, environment assessment, irrigation management, land consolidation or waste management. All these fields also need skills in computer technologies such as geographical information systems or computer aided design. On the other hand, students have to know the landscape, its properties and field and laboratory methods of their evaluation. Field works and terrain recognition are necessary parts of landscape engineer job. Practical field courses are the integral components of the landscape engineering study programme at our faculty. Students have to pass various practical courses during their study. For example Course of Environmental Monitoring, Course of Geodesy, etc. One of them is the practical Course of Hydropedology which enables students to practice analysis of soil and soil water properties. Students learn how to take disturbed and undisturbed soil samples and use them for analysis. They are able to do analysis of hydraulic conductivity, bulk density, soil moisture, etc. Course allows students to do practical analysis directly in field site such as infiltration analysis or hydraulic conductivity analysis. Measurement of river stream velocity or spring discharge is also part of the course. Course usually includes excursion to show students practicing knowledge in praxis (golf resort, water management construction, etc.). The students can apply the obtained knowledge from the course during the field experiments within their theses related to soil water management, soil water holding capacity, water erosion processes or biochar application to the soil. The practical demonstration or possibility for students to try some tasks themselves are the best ways how to lead the students to understand of process. Opportunity to be and feel the landscape is really important for students of this study programme. They have to really live with the nature and landscape to prepare as best as possible improvement projects. Students also confirm that practical education has added value for them. They can better understand context and relationship between elements in landscape. Because of climate change, there is a growing demand for the profession such as a landscape engineer, an expert who sees and understands the landscape and all natural resources.

Key words: *practical course, practice, hydropedology, landscape engineering*

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Creation and implementation of environmental monitoring course in higher education

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The paper presents the results of the project “Environmental Monitoring Course” focused on the preparation of a practical course and teaching texts with the support of other forms of education, and its implementation into education process. The course is obligatory subject for students of second class of Landscape Engineering at bachelor level, both standard and distance students. The aim of the project was to create the practical training supported by literature. There are three outputs of the project, (i) electronic textbook, (ii) practical training, and (iii) printed working procedures. The electronic textbook contains theoretical knowledge about monitoring of selected components of the environment and various ways of its monitoring (<https://moodle.uniag.sk/course/view.php?id=400>). The second part, practical training consists of air, soil and water quality monitoring by several different equipment’s and bioindicators, and waste composition analysis. The training is supplemented by the printed textbook on working procedures in environmental monitoring (Environmental Monitoring Course - working procedures). One extra output was the printed textbook focusing on the issue of water flow in the landscape including practical tasks (Hydromechanics - practical exercises). All of them are available in Slovak language. The main part of the project was to create conditions for acquiring practical skills of students in the form of a practical course. During the course students can practically test in-situ measurements, especially new, modern methods of measurement of selected parameters of water quality, soil, air, and waste analysis. In case of water quality, the students have an opportunity to compare procedures and results of used indicator papers, colorimetric discs, and spectrophotometry. Based on the identified macrozoobentos for the stream and river evaluate water quality by Biomonitoring Working Party Score index. The air quality parameters measure by Aeroqual. Due to restriction caused by virus SARS-CoV-2, the electronic version of the course is highly useable. The practical training was supply by set of indivial tasks related to environmental monitoring by each student in their home conditions, and cover topics of air, water and waste.

Key words: *higher education, environmental monitoring, practical training, textbooks*

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Environmental amateur course

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Environmental amateur course (EAC) is a student project focused to increasing environmental knowledges. The course is primarily aimed for high school students, civil engineering students especially. The content of the course fulfil all above sustainable construction. The main goal of the course is to increase the awareness of high school students about environmental problems with a focus on climate change through the development of a software application. At the same, the one of the goals is to find some changes in the students' behaviour after complete the course by two questionnaire surveys – the first survey will be before the start of the course and the second survey will be after the competition the course. The mentioned course is divided into two parts. The first part includes development of the software application (the website) and the fulfil of the website content. The solution was built in a development environment IntelliJ IDEA. The programming language used is Java with Spring Boot framework. Template engine Thyme leaf was utilized for the visuals, while PostgreSQL was chosen as a database system. The website content fulfil is based on the textbook *Environmental studies in construction*. From the textbook 12 topics are selected. The topics are: Environmentalism, Climate change, Air, Water, Wastewater treatment plant, Waste management, Soil, Landscape, Environmental risks, Building materials, LCA, Indoor environment of the buildings. The aim of the EAC is to teach high school student how to think about buildings and environment. To reach the aim, EAC is designed to 12 topics. Each of the topic includes four sub-topics – Theory, Practice, Test and Task of the weak. Theory part contains some basic terms about the main topic. Theoretical knowledges can be practiced in the next part, which includes some practical tasks. Test can be used as a evaluation tool to find student's knowledges about the theory of the topic. Each test consists of five questions. The last part is Task of the weak. In the Task, students can perform tasks on a weekly basis. For complete all tasks and all test questions, students can earn some points, which are recorded in their profile. These tasks are related to the each of the 12 topics. This course is designed as a non-compulsory subject for high school students. Because of the online teaching which is actually ongoing, the course is designed as an online course.

Key words: *environmental studies, building construction, high school education, development of the website, buildings and environment*

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International projects as a driver for introduction of new practice in educational process

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There are various European and international programs open for Ukrainian academic staff. They provide a set of options for initiation, development and implementation of research, innovation and educational projects. Erasmus+ program is the most well-known in Ukraine. This program provides support for mobility and development of new educational contents. Currently, Karazin Institute of Environmental Sciences is implementing three Erasmus+ projects: Jean Monnet Module “Instruments of the EU Environmental Policy - INENCY”, ERASMUS+ project “Integrated Doctoral Program for Environmental Policy, Management and Technology – INTENSE” and project on academic mobility with University of West Attika, Greece. In the framework of these projects academic staff has great option for familiarization, study and introduction of EU approaches, methods and new techniques in the domain of higher education. They develop and update courses, MOOCs, introduce innovative techniques for students on e-learning. E.g. in the framework of INTENSE project a new integrated PhD program was launched, all methodological materials and supporting documents were prepared, ten new courses for PhD students were developed on the MOODLE platform, currently four MOOCs are finalizing by the project team. Key outputs of INENCY project are lectures (face-to-face and in online format) given by European colleagues as well as development and introduction into education process a new module, consisting from three courses: (i) The economics of global environmental change and environmental management in the EU; (ii) Advanced topics of sustainability – EU environmental policies and sustainable development; and (iii) ICT tools for environmental policy and management. Mobility option is a good opportunity for University teachers to visit EU partner institutions, to participate in conference or workshop, to perform research and to discuss face-to-face specific issues for further actions. Unfortunately, at present due to COVID-19 lockdown, most activities are performing in online format. Anyway, we hope after a year mobilities will be re-started. Such synergism of projects promotes introduction of more detailed info on international activity of the Karazin Institute of Environmental Sciences can be found here: <http://ecology.karazin.ua/mizhnarodna-dijalnist/>

Key words: *ERASMUS+ program, education, international project, innovation education techniques*

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SECTION

Climate change impacts, adaptation and mitigation

Food production and the call to mitigate the effects of climate change

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Climate change is gaining attention among scientists as well as the public. The main role of agriculture is basically to provide the mankind enough food. Changes in the rainfall patterns and in the vegetation period of crops related to increased average air temperature are among the climate change effects on agriculture. The sources of fossil fuels that mainly contributed to an increase of the greenhouse gas effect are getting scarce. Agriculture has to face future challenges where it has to provide food for increasing population, while combating the depletion of fossil fuel resources, increasing risk of soil droughts and decreasing area of agricultural land especially in the developed countries. The diet of mankind varies worldwide significantly due to various reasons (financial, religious, ethical, etc.). According to FAO, the average meat consumption in 2014 was 43 kg per capita worldwide, however in some countries has reached over 100 kg per capita. In Slovakia the average meat consumption in 2017 was 60 kg per capita. As the countries are getting richer, the meat consumption usually increases too. It is estimated that about 26 % of greenhouse gas emission comes from agriculture of which more than half comes from meat production (beef and lamb especially). When talking about climate change mitigation, one should consider the demand of meat and crop production on natural resources. For example, to produce one kilogram of beef meat, 5.7-times more water is needed than for producing one kilogram of soybean. The meat production needs not only more water to produce the feedstock but also requires more land. Taking into account the diverse production systems, beef production needs from 34 up to 151 more land to produce the same amount of protein than soybean. However, globally only 18 % and 37 % of calorie and protein supply come from meat and dairy production. Moreover, the plant-based diet is considered to be “lighter” on digestive system and improves the average health. Despite these facts getting mentioned more and more often, the production and consumption patterns are not changing. There are various reasons on personal and social level for this outcome, however, with governmental support and shifting of subsidies towards plant-based diet this pattern could be changed. Currently the price of meat does not reflect the cost of externalities, which provides customer a cheaper product, however causing more harm to environment. Shifting to a plant-based diet brings various benefits to customers as well as environment while mitigating the climate change impacts. It is necessary to keep in mind that under current global emission scenarios, the more delayed the measures are taken, the more limiting and significant they will have to be.

Key words: *climate change, future challenges for agriculture, plant based diet, emission reduction, emission from agriculture*

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Shelterbelt systems as a means of mitigating the negative effects of climate change on agricultural landscapes

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The area of arable land in Ukraine has increased by more than 25% over the last quarter of the century, so soil protection from degradation is an imperative need. Analysis of natural climatic conditions and the level of anthropogenic impact on agrarian landscapes of Ukraine indicates the urgent need to develop and implement new approaches to stabilize their biological and ecological parameters through the use of agroforestry systems. Natural factors that directly or indirectly affect the efficiency of growing crops in Ukraine are: strong long-term dry winds during the growing season; insufficient rainfall (lack of precipitation); uneven distribution of snow cover; long dry periods and increasing annual amplitudes of air and soil temperatures. These adverse factors can be mitigated by the positive effects of shelterbelts. The formation of a microclimatic condition under a canopy of shelterbelts with various spatial parameters and in the lower parts of the windward and leeward sides are studied. Trends of microclimate formation on both: under a shelterbelt tent and on near-edge sites are revealed. Dense type of construction is less efficient, as significant snow reserves accumulate only under the tent of shelterbelt and on the windward edge of the shelterbelt. It is determined that even the dense shelterbelts if they formed "shelterbelts system", can be effective snow retainers. Soil moisture under the tent of shelterbelt is much inferior to soil moisture in the open field. In dense shelterbelts, soil moisture was lower by 11–31% compared to the open field. Shelterbelts intensively used the moisture reserve in the soil cover, but also contributed to its accumulation in the fields. The maximum values of the soil moisture were obtained at a distance of 30 m from the shelterbelt, which corresponds to $2H$, where, according to the snow survey, the largest volume of snow masses accumulated. It was found that the significant effect of shading from shelterbelt reaches an average of the distance $1.2-1.5H$ from the projection of the trees crown. The length of the shading zone depends on the protective height of the stand and the spatial location of the shelterbelt. Based on the study, the optimal field-protective forest cover was calculated. Instrumental ground research has established that the range of effective protective effect of oak shelterbelts does not exceed $20H$ (for shelterbelts with dense construction – $10-15H$). In this case, the standards for calculating of protection area should be revised. Thus, in the Left Bank Forest-Steppe current protection of fields does not exceed 40 %, which increases the risk of wind erosion processes and leads to a significant shortage of crops.

Key words: *shelterbelts, field protection, English oak, design type.*

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Water retention specification in the landscape to mitigate the possible effects of the global climate change

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The water retention capacity (WRC) is influenced by the land use, the climate, the year season, the type of precipitation and other meteorological factors. The impact of forest on runoff course is more substantial than impact of the other land cover, however it is limited. Due to ongoing global climate change the adaptation and mitigation measures are required for the agricultural landscape. Great diversity of precipitation in the territory leads to greater water abstraction and exhaustion from the areas. Increasing water content in the landscape by the effective systems and methods for water retention in rural areas is focused in this paper. The landscape characteristics significantly contribute to WRC, therefore interventions in the natural outflow regime have a significant impact.

Key words: *climate change, water retention*

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Climate change impact assessment and nature-based mitigation options in flood vulnerable landscapes in Greece

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The assessment of the climate change impact at a basin scale is essential for developing flood mitigation and adaptation plans. This study analyses the variation of the hydrologic regime of the Kalloni river in Lesbos Island, Greece by the examination of possible future climate change scenarios and examines Nature-based solutions (NBS) to provide flood risk mitigation options. The hydraulic simulation model HEC-RAS, which enable the application of flood control management practices for the riverbed and calculate the critical water level for flood-prone areas, was used with satisfactory results. The hydrologic response of the basin was simulated based on Hydrologic Modeling System developed by Hydrologic Engineering Center (HEC-HMS). Weather Generator version 6 from Long Ashton Research Station (LARS-WG 6.0) was utilized to forecast climate data from 2021 to 2080. These forecasted climate data were then assigned as weather inputs to HEC-HMS to downscale the climate predictions of five large-scale general circulation models (GCMs) for three possible emission scenarios (such as RCP 2.6, RCP 4.5, and RCP 8.5). The alteration of the Kalloni hydrologic regime is evaluated by comparing GCMs based estimates of future streamflow with business as usual (BaU) scenario. Variation was noted in forecasting of long-term average discharges, which show increasing trend in autumn and decreasing in the summer. Furthermore, some Nature-based mitigation measures compatible with the needs and characteristics of the case study are examined for the Kalloni landscape. The construction of small dams and ponds in the mountainous part of the watershed for the collection and use of run-off in livestock, but also the increase of soil absorption by reforestation, planting, creation and maintenance of cultivated terraces can enhance the resilience to flooding. This paper provides a quantitative framework for policy-makers in small intermittent flow river basins in the Mediterranean, such as Kalloni, to plan and manage the expected future challenges of river discharge and flood occurrence.

Key words: *climate change, nature-based solutions, HEC-RAS, HEC-HMS, LARS-WG 6.0*

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Impact of climate change on Georgia's Agriculture sector

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Agriculture is a key economic sector in Georgia. Agricultural production heavily depends on climatic conditions. Regional climate change projection significantly increases sector development risks; also, it negatively affects economic and social welfare of the farmers and other vulnerable groups. Under the increase of the concern for food security in the world, mainly caused by water resources shortages, the forecast and determination of crop yield at regional scale has been considered as a strategic topic. This study has been conducted to assess the possible impacts of the climate change on cereal crops productivity and irrigation requirement for two main producing regions of Georgia, according to the current crop pattern, and for the 2050s periods. With this aim, water-driven FAO-AquaCrop model has been used. Furthermore, ongoing and forecasted changes, up to the end of the century, in agro-climatic zones relevant for cereals production have been assessed. The climate change data was generated for RCP4.5 scenario through the global circulation model ECHAM4.1, dynamically downscaled on the region via regional climate model (RegCM4.1). Results show overall increase in cereal crop yields, but also enhancement in water shortages even considering optimum management practices under rainfed conditions. Based on the results obtained, recommendations have been developed for adaptation measures to the climate change for the Georgia Agriculture sector.

Key words: *climate change, Georgia*

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Forest fire risks in Ukraine in the context of climate change

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In recent decades, large forest fires have become more frequent in European countries. Fire season 2020 was the most catastrophic in the modern history of Ukraine, further projections of climate change in Ukraine indicates increasing of fire risks in forests. The Ukraine's forest sector faced unprecedented forest fires. Such fires arose against the background of climate anomalies, which were manifestations of global climate change. Similar trends are observed in other countries, ie the frequency of particularly large forest fires (mega fires) is increasing. It is predicted that such anomalous conditions, which contribute to the occurrence of such fires, will be repeated more and more often.. To assess changes in fire risks in the context of climate change, the forest fire density in the regional aspect is calculated and the main factors that determine the increase of forest fire risk are identified. The highest fire risks according to our study are in the south-eastern regions of the country (Kherson, Luhansk, Dnipro, Zaporizhia and Donetsk regions). Moderate fire risks are also classified in some northern regions of Ukraine (Zhytomyr and Kyiv). The changes in the amount and distribution of precipitation and temperature during the fire season relative to the current normal period under the RCP4.5 scenario until 2050 are estimated. It is determined that the most significant negative impact of climate change will be in the northern regions of Ukraine, especially in Chernihiv and Sumy regions, where the deficit of precipitation during the fire season will reach 60 mm. The average air temperature will increase most significantly in the North-West and in the Central regions of Ukraine. Given that the vast majority of pine forests grow in the Polissya will become more hazardous. Such changes in the distribution of precipitation will lead to an increase in the number of days with extremely high fire danger and increased fire risks. These results indicate that a specific fire risk will be increase in forest areas, which have traditionally been considered as relatively low-hazardous (pine forests growing in moist and wet conditions). Also during prolonged droughts, a significant proportion of fuel from the living and dead groups become ready to burn. In such conditions the significant reserves of forest fuel accumulated, which further increases the fire hazard in such area. Peatlands (especially in northern Ukraine), which are usually too wet for fire occurrence, are projected to be more fire hazardous, which is worth paying special attention taking into account the difficulty of extinguishing peat fires. Thus, the forest fires risks in Northern part of Ukraine will increase over time, which will require the implementation of new approaches to fire management and fuel management.

Key words: *forest fires, wildfires, climate change, fire risk, fire danger*

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Potential of Remote Sensing in Landscape and Urban Water Management Planning

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The current effects of meteorological elements are significantly changing the climatic character of the regions, which we currently refer to as "climate change". The change is essentially reflected across the Earth, where it is currently significantly changing the relatively stable season-related climate in the past. A significant impact is manifested in the occurrence of precipitation and its distribution during the year, mainly in temperature changes affecting mainly vegetation and water supply accumulated in the soil and air, as well as on various parts of the surface. Temperature changes have a significant impact on the water management of specific areas within the agricultural and forestry fund, as well as urban areas and linear transport routes. The effects are also significant in water bodies. All these influences have a significant impact on increasing temperatures in individual parts of our territory. Each part of the territory contributes to a different extent to the increase in temperatures and the use of precipitation during the year. The system of monitoring these adverse effects and the subsequent preparation of measures to eliminate them is provided by modern technologies using the recording of the reflection of electromagnetic radiation from various surfaces. Based on these measurements, it is possible to determine the condition of individual surfaces, analyse their impact on changes in the main climatic characteristics, propose measures to eliminate adverse effects, evaluate elements for regulation and stabilization of water and heat balance, as well as biodiversity throughout the territory. From this point of view, the necessary data are provided by recordings of satellite images in different spectral bands of electromagnetic radiation.

Key words: *Earth remote sensing, spectral bands, climate change, monitoring*

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Carbon dioxide and land use contribution to climate change

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The climate change (as a part of global changes) is the result of natural and anthropogenic issues. Natural reasons of permanent climate change performing through all the history, depend on changing interactions between Earth and outer space. Since the nineteenth century, population increase has caused immense pressure on consumption of food, raw material and energy. To cover this need, started so called industrial revolution characterized by increased fossils fuels combustion followed by carbon dioxide production. Simultaneously, natural surfaces (consuming CO₂ and solar energy) are replaced by artificial ones (buildings, fields, transport and industrial facilities), with decreased evapotranspiration rates. Those effects led to the Earth's energy balance structure change, characterized by air temperature and CO₂ concentration increasing. The role of carbon dioxide as one of greenhouse gases was early understood, but its quantitative contribution to the greenhouse effect was not known. A few years ago, results of measurements published in *Nature*, (2015, 519, 339-345) has shown how much infrared light radiated by the Earth is returned from carbon dioxide in an atmosphere to the Earth. From results of thousands measurement during the decade (2000-2010) it was found the back radiation due to increased CO₂ concentration in average as 0.2 Wm⁻² per decade (0.02 Wm⁻² per year). Since the start of industrial revolution, it is about 1.82 W m⁻². The average income of solar energy to the Earth surface is 350 Wm⁻². It was estimated about 60% of dryland of the Earth is anthropogenically modified, so the energy balance of such surfaces is strongly changed. Usually, natural surfaces are replaced by artificial ones, rain forests are replaced by fields, residential and industrial buildings, or by transportation infrastructure. Common feature of such changes is evapotranspiration decrease and outflow increase. Transpiration decrease of rain forests (RF) is critical, because of high precipitation totals per year (2500 mm), from which about 90% evaporates and therefore up to 90% of incoming radiation is used as latent heat of evaporation. But anthropogenically modified surfaces replacing RF evaporate less than half of the natural (RF) evapotranspiration. According to FAO, about 100 000 km² of RF are eliminated annually over the globe. To go this way, to the end of this century all the RF will be cleared. Assuming decreasing of evapotranspiration to one half, 82 MW km⁻² (or 82 Wm⁻²) of energy will be heating boundary layer of an atmosphere and thus contributing to the increase of air temperature. Recalculating this amount of energy saved by decreasing evapotranspiration, to the globe area, it is 0.016 Wm⁻², close to the radiative forcing by CO₂. It should be mentioned that energy is not dissipated regularly along the globe, so locally air temperature increase due to saved energy contribution will be much higher. In conditions of Slovakia, to replace forests by fields, transportation infrastructure or buildings, additional 20 MW km⁻² (or 20 Wm⁻²) of energy will be spent to the biosphere heating, thus increasing air temperature in boundary layer of an atmosphere. This contribution would like to show, that contemporary land use change can significantly contribute to global warming thus changing climate in biosphere. Therefore, existence of "green" surfaces on the Earth is basic precondition to avoid dangerous climate change.

Key words: *land use, carbon dioxide, climate change*

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Nutrient leaching from top layer of arable sod-podzolic sandy loam soil amended with fertilizer and biochar

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Leaching of nutrients from arable soils can deplete soil fertility, increase fertilizer costs, reduce crop yields, and pose a threat of environmental pollution. Therefore, a very important area of research is the development of effective ways to retain nutrients in soils. One of such methods could be application of biochar to agricultural soils. So far, it was found that biochar application to soils can be an effective way to control nutrient leaching in agricultural production, but there is still not enough information available on the subject of biochar short-term effect on the mobility of nutrients in agricultural soils, particularly immediately after fertilizer application to the soil in the conditions of heavy rain. This is important for addressing the issue of biochar's ability to influence the leaching or redistribution of nutrients in the soil at the very early stage after fertilizer application when the plants are not there to prevent the nutrient losses. The purpose of this study was to assess the effect of biochar on the leaching of main nutrients from the arable horizon of soddy-podzolic sandy loam soil of North-Western Russia straight after application of mineral fertilizer under heavy precipitation. The short-term laboratory experiment included six treatments in four replicates: S – control soil; SB10 – soil + biochar (10 t ha⁻¹); SB20 – soil + biochar (20 t ha⁻¹); SF – soil + fertilizer; SFB10 – soil + biochar (10 t ha⁻¹) + fertilizer; SFB20 – soil + biochar (20 t ha⁻¹) + fertilizer. The soil in the cylinders was watered with high rates of distilled water, corresponding to the maximum amount of daily precipitation observed in the area. The leachate was collected and tested for pH, available N, K and P. At the end of the experiment, the soil cylinders were disassembled, the soil samples were dried, and the pH_{H2O} values, as well as the concentration of available N, K and P were determined in the samples. The Shapiro-Wilk test was used to find out whether the obtained results were normally distributed and as the distribution was not normal, the nonparametric statistics was used for the data analyses. The results of the experiment have shown that the effect of biochar on the movement and accumulation of main nutrients in the soil after fertilizer application and under the effect of high precipitation rates was more pronounced at the higher application rate of 20 t ha⁻¹. Biochar application was reducing acidity of the leachate and, also, the soil acidity. Nitrogen in ammonium form, available potassium and phosphorus were retained in the soil through biochar application for a short period of time while nitrate leaching was not affected. Overall, biochar can be used as a soil ameliorant of arable sod-podzolic sandy loam soils of North-Western Russia as even a short delay in the nutrient leaching is potentially beneficial to nutrient utilization of crops.

Key words: *precipitation, biochar, fertilizer, nutrients, leaching, light textured soil*

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Multiyear effect biochar application on soil N₂O emission, soil properties and crop yields in Haplic Luvisol

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There are a lot of studies dealing with the effect of biochar application to agricultural soils and its impact on the nitrous oxide emissions (N₂O), soil properties and yields. However there is still a dearth of knowledge on the response of above parameters after biochar amendments, particularly for longer-term or repeated applications. Therefore, the aim of this study was to evaluate the changes in the N₂O emissions, soil physical and chemical properties, and crop yields of a silty loam Haplic Luvisol after biochar application (0, 10 and 20 t.ha⁻¹) combined with or without N-fertilizer (three levels: N0, N1, N2) during the years 2014-2016 and after re-application of biochar (the same rates as in 2014) in 2018 (Experimental site of SUA-Nitra, Dolná Malanta, Slovakia). Initial biochar application in 2014 combined with and without N-fertilizer, decreased cumulative N₂O emissions by 2-39 %, improved the soil properties such as soil pH (from acidic towards moderately acidic), soil organic carbon (SOC) (increase by 8-79%), bulk density (increase of BD) and soil water retention (soil moisture increase by 1-15%) in all monitored years (2014-2016). There was found no effect of biochar amendment on mineral nitrogen (NO₃⁻ and NH₄⁺) during 2014-2016. The ability of biochar to increase the grain yields over the monitored period ranged from 1% up to 42%, but this effect of biochar significantly diminished two years after its application to the soil (no effect in 2016). The results of monitored period in 2018 with initial and re-applied biochar showed that biochar was able to improve the soil properties such as soil pH(KCl), soil organic carbon (increase from 4 - 100%), soil water availability (an increase from 1% to 15%), saturated hydraulic conductivity (an increase from 5% to 95%). The effects were more significant in the following cases: repeated rather than single biochar application, higher rather than lower biochar application rates, and higher rather than lower N fertilization levels. Initial and repeated biochar applications also reduce cumulative N₂O emission in 2018 (from 1-34%). According to our results, a single biochar application, as well as reapplication, to these soils, with or without N-fertilizer, appears to be a promising practice to improve the sustainability of intensive agriculture.

Key words: *biochar, Luvisol, N₂O emissions, soil properties, yields, nitrogen fertilization*

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Effect of Biochar application on CO₂ Emissions from Haplic Luvisol with or without N-fertilizer

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Existing literature finds biochar as a byproduct of biomass pyrolysis and a carbon-rich material which can be utilized for agricultural purpose to enhance the quality of soil and its crop productivity. However, there is a dearth of information for understanding the influence of biochar application on the emission of greenhouse gases which have major impact on various atmospheric parameters, climate change and global warming. Present experimental field study investigates the effects of biochar with or without N-fertilizer on CO₂ emissions from Haplic Luvisol (silt loam) of Malanta site near Nitra in Slovakia. In the study, Haplic Luvisol was treated with biochar (produced by the pyrolysis of paper fiber sludge and grain husk at the temperature of 550°C for 30 minutes in Pyreg reactor) doses of 0 t.ha⁻¹ (B0), 10 t.ha⁻¹ (B10) and 20 t.ha⁻¹ (B20) in 2014. Each of these biochar amendments were combined in three levels (N0, N1, N2) of N-fertilizer. The fertilization level of N1 was 40 kg.ha⁻¹ and N2 was 80 kg.ha⁻¹ in 2018 whereas these were 108 kg.ha⁻¹ and 162 kg.ha⁻¹ in 2019. Different amendments with N-fertilizer were designated as B0N1, B0N2, B10N1, B10N2, B20N1 and B20N2 while these were denoted by B0N0 (bare HL), B10N0 and B20N0 when no N-fertilized was used. All of these treatments were studied in field conditions to investigate the influence of biochar application on CO₂ emissions from HL during spring season (April – June) in 2018 and 2019. It was found that cumulative CO₂ emission was lower in 2019 as compared to 2018. Cumulative CO₂ emissions from B10N0 and B20N0 in 2018 were reduced by 12% and 13% respectively as compared to its control B0N0. The cumulative CO₂ emissions from biochar treatments combined with both fertilization levels (B10N1, B20N2) were also lowered by 14% and 37%, respectively. However, the cumulative CO₂ emissions for B20N1 and B10N2 were increased by 4% and 10% respectively in comparison to their control treatments (B0N1 and B0N2). In 2019, the cumulative CO₂ emission from B10N0 was decreased by 13% whereas it was increased by 21% for B20N0 as compared to its control B0N0. The cumulative CO₂ emissions for B10N1 and B20N1 were maximized by 72% and 191%, respectively in comparison to their control B0N1. Opposite observation was found in case of B10N2 and B20N2 where the cumulative CO₂ emissions were reduced by 27% and 29% as compared to their control B0N2. Correlation between average CO₂ emissions and soil moisture, soil temperature, soil pH, NO₃⁻ and NH₄⁺ were also studied. Significant correlation ($r^2 = 0.80-0.89$; *P < 0.05; ** P < 0.01) was found only with the soil temperature measured in 2019 for all the treatments other than B10N0, B10N1 and B20N2. According to experimental results, it can be concluded that the biochar applied in 2014 is still able to reduce CO₂ emissions from some treatments during spring season even after five or six years of its application.

Key words: CO₂ emission, biochar, Haplic Luvisol, N-fertilizer

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Effect of biochar application and re-application on the soil water content of agriculturally used soil

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Biochar is a heterogeneous carbon-rich material which is formed in the process of thermochemical conversion (mostly by pyrolysis) of biomass under strictly controlled conditions, such as the residence time of biomass in the reactor, pyrolysis temperature, and the composition of the atmosphere providing an anaerobic environment. During the pyrolysis process, the complex organic structures within biomass decompose at temperature from 350 up to 800 °C. Today, biochar is an effective tool in the environmental management. It is used to sequester carbon in the soil while also improving the soil properties as well as the overall soil quality. The biochar field experiment located in Dolná Malanta (Nitra, Slovakia) was established in 2014 in order to evaluate the impact of biochar application on greenhouse gas emissions from the soil, on the soil properties, soil quality and crop production. The experimental treatments were divided into treatments without biochar (B0), with biochar at dose of 10 t.ha⁻¹ (B10) and with biochar at a dose of 20 t.ha⁻¹ (B20) and each of these doses of biochar were combined with three levels of nitrogen fertilization (N0, N1 and N2). All treatments were based on three replicates on plots of 4 x 6 m. In 2018 treatments with applied biochar were divided into halves and on one of them biochar was re-applied in the same doses in 2014. These treatments were marked with abbreviation „reap“ (B10reap, B20reap). The aim of the contribution was to evaluate the impact of applied biochar (in 2014) and re-applied biochar (in 2018) alone or in combination with nitrogen fertilizer on the soil water content. Soil sampling for determination of soil water content was carried out continuously during the growing season of spring barley (*Hordeum vulgare* L.) in 2018, maize (*Zea mays* L.) in 2019 and pea (*Pisum sativum* L.) in 2020. The disturbed soil samples were dried at 105 °C and the soil water content was calculated by standard gravimetric method. The results confirmed a more favourable effect of a higher dose of biochar (application and re-application) on soil water content. A higher ratio of the measurements with an increase in soil water content to the total number of performed measurements were observed at a higher biochar application dose compared to the control treatment B0+N0. For example, in 2018, soil water content increased at treatment with re-applied biochar at a dose of 20 t.ha⁻¹ with nitrogen fertilizer at level N2 (B20reap+N2) in 10 terms out of a total of 13, with an increase ranging from 5 up to 55%.

Key words: *soil water content, biochar application, biochar re-application, nitrogen fertilizer application*

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Treatment of methylene blue contaminated wastewater by biomass not exposed to industrial wastewater

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Sequencing batch reactors were operated for the assimilation of aqueous methylene blue by aerobic biological method. Biomass were collected from different sources of C. V. Raman Global University and were acclimatized using methylene blue dye simulated as synthetic textile industry wastewater. The biomass collected from RIHC front, central canteen, back gate and civil department front proved to be successful for the degradation of synthetic textile wastewater. Hydraulic retention time (HRT) was varied at four levels, such as 27 h, 30 h, 34 h and 40 h and the reactor with biomass from the back gate was able to show 99% efficiency of total dissolved solids (TDS) removal at 34 h HRT. The data received from the back gate biomass was subjected to modelling analysis. The experimental data followed Modified Stover-Kincanon model and Grau's second order model with high coefficient of determination.

Key words: *Sequencing batch reactors; textile wastewater; total dissolved solids; modified Stover-Kincanon model; Grau's second order model*

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Vplyv rôznej úrovne caespestechniky na rozvoj koreňového systému trávnik

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The aim of the experiment was therefore to examine the possibility of using selected soil conditioners for development of the turf root system. The Experiment was carried out in the area of Oponice, district Topolčany between the years 2016 and 2018. The area climate is characterized as warm, slightly humid, with mild winters. The average daily temperature per year is 7.4°C, and during the vegetation period 13.6°C. The average annual rainfall is 593.0 mm, during the vegetation period 338.0 mm. In this article we are presenting the results after three years of land management. To examine the impact of soil conditioners with NPK fertilization, a small-lot experiment in raised wooden boxes with dimensions 2 x 5 m was established. The boxes were filled with quartz sand marked as SH 34 of pH 7 with fraction 0.1 mm – 0.4 mm. A grass mix of the species *Lolium perenne* L. and *Poa pratensis* L. was used. The seeding amount was 25 g.m⁻². We were observing 6 variants in total: Variant A: Alga 600 was applied 2 times per month by spraying on the leaves in a dosage of 0.5 kg.ha⁻¹, Variant B: RootMost applied in a dosage of 1 l.ha⁻¹ in a 10 days interval by spraying on the leaves, Variant C: Vulkagran G[®] was during establishing of the experiment applied once in strips in dosage of 100 g.m⁻², Variant D: Hack Bazalt 100 g.m⁻², applied once in strips during establishing, Variant E: Agrosil[®] LR was applied once during establishing of the experiment in a dosage of 100 g.m⁻², Variant F: control sample – unfertilized variant. After three years of research (2018) it was found, that in sandy conditions, the largest root system was in case of application of the combination Agrosil LR + NPK (457.36 g.m⁻²). Only slightly lower root formation was present in a variant with the fertilizers Root most + NPK (418.10 g.m⁻²). The lowest production of roots was paradoxically found in case of combination of fertilizers Vulkagran G[®] + NPK with the value of (288.47 g.m⁻²) and almost the lowest production of roots was in case of control sample (289.65 g.m⁻²). The highest value of the stubble was found in case of combination of Agrosil[®] LR + NPK (1189.49 g.m⁻²). The impact of conditioners was manifested fully and the provably lowest weight had the stubble in the control sample without the application of conditioners (655.58g.m⁻²). The development of above-ground mass was most supported, with minimal differences, by ALGA 600, Vulkagran and RootMost. However, Hack Basalt had a demonstrably lower stimulatory effect on the growth of aboveground phytomass. In terms of the influence of the used conditioners on the agrochemical properties of the soil, we observed an inconclusive effect on the content of N, K and Cox. There was a significant increase in P content, but only with the application of Agrosil-LR. Sorption capacity (CEC) was also significantly affected. Most products with Vulkagra and ALGA 600. All conditioners decreased compared to pH control, the most and demonstrably ALGA 600 and Vulkagran. In the utilization of the supplied nutrients by the roots, all conditioners increased the P and N content. The N content in the stubble increased the use of Hack Basalt the most. Utilization of P was most supported by the application of Agrosil-LR. All used conditioners supported, resp. increased the utilization of supplied nutrients in the above-ground matter. In P inconclusively, in N and K, however, Vulkagran in particular increased their intake in evidence.

Key words: lawn, soil conditioners, fertilization, roots, variants, substrate, perennial ryegrass (*Lolium perenne*), common meadow grass (*Poa pratensis*)

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Radial growth measurements and rainfall impact during budbreak period of Royal walnut (*Juglans regia* L. var. Chandler) in 2019

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Over the years of research has become clear that human industrial development has caused releasing heat-trapping gases since beginning of 20th century. Global climate change is affecting environment not only by rising average temperatures but also by the rising level of the seas and oceans, extreme weather events, changes in precipitation distribution, shifting wildlife habitats and many other. One of the causes of climate change is drought, which is caused by a combination of high air temperatures and periods without precipitation. Drought is the most important constraint to the yield of agricultural production. Our research was focused on rainfall impact on radial branch changes of Royal walnut (*Juglans regia* L.) during budbreak. The research was conducted on tree samples in the orchard located in an agricultural area of the city of Nové Zámky in southwest Slovakia. The climate in this region is very dry and warm with an average annual temperate of 9 – 10 °C and total annual precipitation on average of 500 – 550 mm (Klimatický atlas SR, 2021). Royal walnut is a water-intensive species that requires 900 mm of rainfall during the growing season. Radial branch changes were measured by high-precision dendrometers DD-S and datalogger DL-18. The dynamics of radial stem changes are mainly determined by water transport in xylem vessels, which caused expansion and shrinkage of stem diameter, and it can be used to quantify water stress. The zero-growth concept is a method used to specify period without stem shrinkage to determine irreversible radial stem growth. Our measurements were taken in May 2019 on 3 tree samples. During this period were measured 29.8 mm. The precipitation in May was distributed unevenly. While the highest amount of precipitation 6.6 mm fell on 5th of May small amount (0.2-2 mm) fell until the 16th of May. Since the beginning of the research was measured small daily irreversible branch expansion, which was the result of water storage refill during the night. By applying zero-growth concept to measured radial changes, the water shortage period was observed from 13th to 20th May, when fell 2.8 mm of precipitation. After this water income tree started to refill internal water storage and branch tissue started to expand. From 20th to 31st May was not measured longer period of water shortage what was result of rainfall amount and distribution over last days of measured period. During the budbreak period has tree higher water demand due to leaf development. As a consequence of global changes scientists expect changes in average air temperature during the vegetation period which will cause the prolongation of the vegetation period of agriculturally important species.

Key words: *water shortage, drought, walnut, rainfall, radial changes*

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Evaluation of meteorological and hydrological conditions in the Nitra river basin in 2020

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Globally, 2020 was one of three warmest years on record. Europe saw its warmest year, winter and autumn on record. Wet and dry conditions varied substantially across the region and the year. In line with the high number of sunshine hours, cloud cover was at a record low for 2020. While precipitation levels were average for the year, there was a wide range of anomalies between regions and between different times of year (ESOCT, 2020). The Nitra river basin has an oblong shape in north-south direction. The basin was divided into three parts – northern (meteorological station Dolné Naštice and hydrological stations Bystričany and Solčany), center (meteorological station Nitra and hydrological station Koliňany) and southern (meteorological station Mužla and hydrological station Pribeta) – for better analysis of climate condition. Global radiation, air temperature, precipitation, relative humidity and soil moisture were analyzed and compared with climatic normal (1951-2000). The work clearly shows that in the northern part of the basin in the locality of Dolné Naštice there were no dry periods from the point of view of Walter's climatogram. In the Nitra locality, there were two dry periods in 2020, from the middle of March to the end of April and from the first third of June to the end of August. In the southernmost part of the basin in the Mužla locality, with Walter's climatogram, the entire vegetation period represented a precipitation deficit, which was caused by a lack of precipitation and high average temperatures, which were above the long-term climate normal, except in May. Soil moisture can show really important information from agricultural point of view. It is important to keep soil moisture above wilting point, point of lower availability respectively. Soil moisture ran under the wilting point value and also under point of lower availability value during summer period in every locality, except Pribeta. On the other hand, Pribeta (southern part) had long term period with soil moisture under the point of lower availability value. Soil moisture ran under hydrolimits regularly but often only on short time in northern or central part. This example shows, that when we want to analyze agricultural and meteorological condition we have to focus on as many aspect as possible.

Key words: *air temperature, precipitation, global radiation, humidity, soil moisture*

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Degradation of glaciers of basin of the river Pirikiti Alazani (Georgia) due to climate change

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In the article, the dynamics of degradation of the river Pirikiti Alazani glacial basin glaciers is discussed on the background of the current climate change. Based on the integrated survey, the state of the glaciers in this basin at the initial (at the time of issuing of the catalogue -1964), medium (2006) and final (2020) time points are given. The characteristics of the glaciers (number, area) at the medium and final moments are determined using high-resolution satellites. A comparison of these conditions showed that climate change is non-linear, making glacier degradation more intense in the second period than in the first one. If the number of glaciers has shrunk by 28.6% in the first 50 years of the 60 years, correspondingly this reduction is 70% over the last decade. If during the first period the area covered by glaciers decreased by 56%, in the second period it decreased by 75.7%. This can be explained by two factors: first, that climate change development has non-linear character and second, that climate change impacts on smaller glaciers are more intense.

Keywords: *climate change; glaciers, satellite remote sensing*

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Assessing soils vulnerability to agricultural drought: a Belarusian Polesye case study

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The climate warming observed in the last three decades on the territory of Belarus has led to the development of droughts. Their negative impact is most acutely manifested in the Belarusian Polesye - the southern region of the republic, where the total area of agricultural land is more than 2.9 million hectares. Over a 75-year period of meteorological observations, the frequency of occurrence of atmospheric and agricultural droughts has noticeably increased. So, during 1989-2020 the frequency of severe droughts during the growing season (April – October) was about 80%. Onset of agricultural droughts in time can differ significantly from the onset of meteorological droughts, depending on the available moisture reserves in the soils before the onset of the dry period. In this regard, they were used as a key characteristic that determines the degree of soil vulnerability to droughts. To assess the influence of soil moisture reserves, two agrohydrological soil constants were used: the lowest moisture capacity, or total field moisture capacity (TFMC) and capillary rupture moisture (CRM). The last constant means the initial degree of damage to plants from drought and arid events and serves as an important criterion for determining the degree of soil vulnerability to such events. The most informative from the point of view of a quantitative assessment of the moisture content of soils of different genesis and granulometric composition is the 0-20 cm soil layer, in which the root system of plants is mainly concentrated. The initial data for assessing the vulnerability of soils to droughts were data on the moisture content of soils in the 0-20 cm layer, using ten-day resolution data obtained at 17 meteorological stations of the Belarusian Polesye during the growing season (April-October) for a 30-year period (1989-2018). According to the ratio of the number of days during the growing season with soil moisture less than the value of the CRM in the 0–20 cm layer, all studied soils were divided into 4 groups: the most vulnerable - more than 130 days; highly vulnerable - 91-130 days; moderately vulnerable - 50-90 days; weakly vulnerable - less than 50 days. As a result of the conducted research, it was found that the share of the most and strongly vulnerable to drought soils of agricultural lands occupy 29.8%. These agricultural lands require priority and urgent measures of an agro-technological and territorial-organizational nature to prevent or mitigate the consequences of the manifestation of arid phenomena on them. The area of soils that are moderately vulnerable to droughts is 29.2%, weakly vulnerable - 40.1%.

Key words: *drought, soil moisture, vulnerability, soil hydrological indices, crop water deficit*

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SECTION

**Biological, ecological, agricultural and technical measures in
land consolidation in relation to climate change**

The influence of climate on the occurrence of forest and landscape fires in the left-bank forest steppe of Ukraine

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The issue of global warming is becoming more important for every country in the world for last time. In the last some years, it has been during dry weather conditions in many Eurasian countries, as well as in the United States and Canada, and Australia, that fires have become large-scale and have had the large negative consequences. Mainly regions in Ukraine are not an exception to this negative situation, where in recent years there have been significant in area and scale both landscape and forest fires, which have led to huge negative consequences. The results of research of the influence of the main climatic factors for the growing period on the tendencies of fires on the territory of the Left Bank Forest-Steppe of Ukraine for the period 2006–2019 are given. As a climatic criterion of moisture supply and determination of dry years, a relative indicator was used - the hydrothermal coefficient of Selyaninov. To determine the anomaly of temperature and precipitation in the studied area, the approach proposed by Babychenko V. was used, according to which this criterion of humidity of years was calculated as the standard deviation (σ) from the long-term mean values. The calculated criteria of anomaly of weather conditions made it possible to compare them trends with numbers of fires in the Left Bank Forest-Steppe of Ukraine and two the forest enterprises located at different distances (0.5 and 20 km) from the Kharkiv. That is, due to the difference in population density of certain areas, anthropogenic factor is additionally taken into account as one of the main factors influencing the peculiarities of fire trends On the enterprise "Zhovtneve Forestry" located at a 20 km distance from Kharkiv compared to the Kharkiv Forest Research Station located on 0.5 km distance from Kharkiv, the number of fires was more higher due to a large percent of fire-hazardous pine stands. The comparison of trends of fires was carried out taking into account the percent (%) of the total number of fire cases for the entire studied period. This approach made it possible to better compare all the studied areas regarding of the number of fire cases with the main climatic indexes as well as to determine how strongly influenced by weather anomalies or anthropogenic factors on fire trends. The results of these studies showed the hydrothermal coefficient of Selyaninov is the best index for analysis of influence of climate on fires. Precipitation and average temperature are less pronounced. Despite the high level of humidity in 2014, the number of fires in the Left Bank Forest-Steppe was maximum (10,515 cases) due to the start of hostilities.

Key words: *air temperature and humidity, climate, forest fires, landscape fires, the hydrothermal coefficient of Selyaninov*

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The influence of biochar on agricultural soils in the south of the Far East of Russia

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A relatively new and actively developed field of research in soil science and Agroecology using of biochar for improving the chemical, physical and biological characteristics of the soil for sustainable, environmentally safe increase in yield is. In recent decades, many countries have actively investigated the mechanisms that underlie the positive effects of biochar on soils and crops, but many agroecological aspects of the biochar using are still unclear, which is especially important for Russia with a high variety of soil cover. The results of the biochar application in drainage and drainage-free plots of the Luvic Anthrosols are presented for the biochar applying doses of 1 and 3 kg/m² in the conditions of the Primorsky territory. During the first growing season the applied biochars have been essentially physically grinded with significant increasing their specific active surface and water-holding capacity. There was observed the obvious positive effect of biochar application on the investigated Luvic Anthrosols' hydrophysical properties and organic carbon content too after the growing season. As a principal result crops' yield increased up to three times in the experiment versions with biochar dose of 3 kg/m² at the plots without drainage. At the same time there wasn't observed the significant increasing in the crops' yield at the plots with drainage. The obtained results allow to give primary assessment of the agroecological efficiency of biochar application in case of the Russian Far East Luvic Anthrosols with obvious limiting factor of seasonal waterlogging, including into account as principal soil features changes as potentially most profitable vegetable crops' yield. The use of biochar on the Luvic Anthrosols is accompanied by its significant physical grinding already during the first growing season, which contributes to a significant increase in its specific active surface and water-holding capacity. Changing the properties of biochar is faster in Luvic Anthrosols without a drainage system than in a field with a drainage system. The largest positive agri-environmental effect of biochar making with the improvement of hydrophysical indicators, increase of organic carbon content and fold increase in yield of cabbage is observed on hydrotechnical not reclaimed Luvic Anthrosols (in areas without drainage), indicating that the prospects for its use as an effective meliorant on the natural soils of the South of Primorsky region – in the case of economic or environmental unreasonableness there hydrotechnical melioration measures. The research was carried out with the financial support of the Russian Foundation for basic research under project No. 19-29-05166.

Key words: *biochar, Luvic Anthrosols, land agroecological quality, porosity, water-retaining capacity, agroecology.*

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Influence of climate change on the radial growth of Scots pine (*Pinus sylvestris* L.) in the Forest-Steppe, Ukraine

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Knowledge of the response of tree rings to past conditions can help predict how forests may respond to future climates. Dendrochronological studies use higher sensitivity to climate as a sign of increased risk of tree mortality. The influence of climate on the radial growth of *Pinus Sylvestris* L. in the stands of the Left-Bank Forest-Steppe, growing on the weak sod-podzolic soils has been studied. Standard dendrochronological methods are used. The cores were selected by a Presler drill from 15-20 Scots pine trees in a tree groups. Tree ring widths were measured with HENSON digital equipment with an accuracy of 0.01 mm. Cross-dating analysis shows the exact calendar date of each tree ring. Later the quality of the tree ring series was checked by the COFECHA program. Core segments with low correlation values were excluded from analysis. Indexing of tree ring series were performed using the ARSTAN program. The relationship between climate and the radial growth has been identified through the RESPONSE program. The concept of "norm" is the average values of air temperature and precipitation for the period 1960-2017 from Kharkiv meteorological station. Deviations from the norm of precipitation and temperatures for years with extreme weather events (droughts, cold winters, etc.) are expressed as a percentage and used to characterize the pointer years. A regional tree-ring chronology of Scots pine for Left-bank forest-steppe has been created, which consists of 80 individual tree-ring series and is based on 6 local tree-ring chronologies. This pine series is suitable for dendroclimatic analysis, because it has high values of inter-series correlation coefficient, EPS coefficient exceeding the threshold of 0.85 and medium sensitivity. The pointer years of minimal radial growth (1936, 1942, 1954, 1975, 1979, 2000, 2005, 2009 and 2012) were revealed, during which the width of tree ring width was lower than in the previous year by 20-46%. These years were characterized by droughts during the growing season (1975, 1979, and 2009) and extreme summer (2000, 2000, and 2012), winter and early spring temperatures (1979, 2005). Radial growth during the minimum pointer years was limited by the deficit of precipitation in the growing season (deviations from the norm were lower by 54 - 63%), high temperatures during the growing season (deviations from the norm above 9-15%), low and high winter temperatures (deviations from the norm was lower and higher than 40%), high March temperatures (exceeding the norm reached 70%). The years of maximum growth (1935, 1943, 1953, 1988, 2004, 2011, and 2014) were characterized by a favourable ratio of heat and moisture. Exceedance of precipitation norm was higher than 24-31% in April-August. Until 1979, during the minimum pointer years, radial growth was limited by low temperatures and droughts, but after 1979 - only droughts and warm winters. A comparison of the response of the radial growth of Scots pine to climate variation during 1960-1988 and 1989-2017 revealed an increase in the sensitivity of trees to climate change. Despite the plasticity of pine and its adaptation to climate change at this stage, we can expect deterioration in Scots pine radial growth in the coming years.

Key words: *climate change; tree rings; Scots pine; pointer years; sensitive*

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Spectral manifestations of the plant growth depending on the applied compost amount

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The of agricultural production quality depends on a number of factors such as climate change, limited rainfall, increasing temperature differences, water and soil quality, technological processes, the fertilizers exploitation. Sustainable agriculture with an emphasis on recycling should use and incorporate the composted material into soil, which is becoming increasingly important. In order to support plant growth as much as possible, it is necessary to determine the optimal amount of incorporated compost into the soil. In agriculture, the Earth remote sensing methods have a wide application. With their help we can determine the quality of the vegetation cover, possible damage to the crop, but also analyse the amount of water on the cultivated area. The scanned plants are manifested by specific reflectivity in the individual bands of the electromagnetic radiation. Visible radiation provides information about the state of the photosynthetic apparatus and the infrared spectrum about the amount of biomass. The aim was the laboratory monitoring of the plant spectral manifestations, grown in various substrate mixtures and in the compost from an urban composting plant. Using the ALTA II spectrometer, the reflection on annual sunflower leaves in selected spectral bands was determined under laboratory conditions. Reflection changes were observed depending on the gradual plants drying grown in the basic substrate, into compost and their combinations in different ratios. In general, the highest values of reflection were shown by the samples in the combination of substrate + compost in a ratio of 1: 3, which represented the plant in the best condition. The measured reflections in the visible spectrum did not change significantly depending on the humidity decrease. The changes were more pronounced when measured in the infrared spectrum. When we know the spectral characteristics and reflection curves of the individual plants behaviour, it is easier to evaluate larger agricultural areas covered with vegetation, captured by the unmanned aerial systems.

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Key words: *Earth remote sensing, reflection, spectrometer, compost, annual sunflower*

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SECTION

Effect of water management protection structures on landscape protection from drought and floods

Blue-green infrastructure in a landscape adapting to current climatic conditions

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Today, we are increasingly relying on the knowledge of how cities are managing water in response to increasingly frequent manifestations of climate change such as extreme rainfall, drier summers and other undesirable effects. Approaches to 'living with water and making space for water' are increasingly being adopted internationally, addressing the whole water spectrum (floods to droughts). These include, for example, the Dutch 'Room for the River' programme and Australian initiatives for water-sensitive urban design, among others. These approaches are essential components of visions for a blue-green future. A future that embraces blue-green principles is characterised by a resilient and sustainable approach to flood and water management. Nature-based solutions, sustainable drainage systems and blue-green infrastructure (e.g. green roofs, retention strips, rain gardens, detention basins and ponds) are widely used. These approaches enrich society by providing multiple co-benefits. These include, for example, access to public green space, recreational opportunities, aesthetic improvements and better management of environmental processes such as flooding, drought, urban heat, water and air pollution. In this paper, we focus on four cities that are known for advances in blue-green infrastructure but have different approaches to the proper functioning and perception of urban water management. These are Newcastle (UK) - Newcastle Declaration on Blue and Green Infrastructure; Rotterdam (Netherlands) - Rotterdam Urban Water Plans; Ningbo (China) - Chinese Sponge City Program; Portland, Oregon (USA) - Citywide Blue-Green Infrastructure for Stormwater Management. The aim of the study is how blue-green visions were developed in these cities, what the driving forces behind them were and how the lessons could be applied to cities in Slovakia. By analysing and exploring the ways in which it can help build capacity, we examine how new forms of environmentally sustainable urban management can be developed to address current water management challenges. In this paper we will seek to show how blue-green infrastructure can meet other urban objectives, in this case by creating new habitats and increasing biodiversity in an area of poor ecological value.

Key words: *blue-green infrastructure, climate change adaptation, nature-based solutions, urban resilience, urban design, rain water*

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Green roofs for cities surface runoff regulation

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Green urban space in Post-Soviet Union countries is a disparate network of linear and planar plantations. At the same time, the modern practice of construction, especially in large cities with a population of more than 1 million people, has a continuous using of “grey” solution. In turn, this leads to lower living space quality, dust and air quality, increment of urban heat, deregulation of surface runoff, reduced city's ability to climate change adaptation, and reduced aesthetic qualities of the surrounding urban space. The concept of green infrastructure, which is used in many countries and cities around the world, is the best way to reorganize urban space into sustainability cities. Moreover, although the methods and forms of organization of green infrastructure are different in each city according to geographical, environmental, socio-economic conditions, the goals they pursue remain the same. Identification and expansion of green infrastructure is one of the most important strategies for implementing an ecosystem approach to spatial planning. The use of green infrastructure in urban conditions contributes to the development of spatial processes, planning and management of which draws special attention to the impact of non-environmental solutions generated by the urban context. One of the types of landscaping is the creation of green roofs on different types of buildings. According to statistics, the total area of existing greenery in Kharkiv is about 15.4 hectares or 44% of the total area of the city. However, almost half of all greenery has a significant age threshold. In other words, the level of landscaping in Kharkiv is not more than 25% - 30% with a regulatory value of 45%. In the research was studied the frequency of use of green roofs in construction and landscaping on the example of Kharkiv. Also, was conducted an inventory of green roofs in Kharkiv. Were taken samples for chemical analysis of surface runoff, samples from flat and sloping roofs, snow samples, chemical analysis of surface runoff water from green roofs for the content of pollutants. Modern urbanization processes in Kharkiv are accompanied by an increase in anthropogenic pressure on the natural component, compaction of buildings and reduction of green areas. Delaying surface runoff with green roofs will help eliminate flooding of the city. At the same time, the creation of new large objects is a rather complex process in the structure of the green zone of the city. The creation of green roofs during construction currently has several advantages - they also provide economic benefits: a more integrated use of building space. Moreover, the construction of green roofs is suitable for commercial institutions and private households.

Key words: *green infrastructure, green roofs, stormwater regulation, urban water, surface runoff*

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Change of flow in drainage channels by reverse water flow from a recipient

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Drainage of the territory in the lowland areas of Slovakia was conceptually solved by complex drainage systems, the main purpose of which was to drain surface waters from the collecting area through a channel network with the possibility of gravitational discharge of excess drainage waters from detailed drainage systems (secondary channel network, subsurface drainage). The drainage system consists of a set of water management facilities over a large area from which internal waters are diverted to a main drainage channel. The main drainage channel conveys these waters mostly to a drainage pumping station at the impounded watercourse, where they are pumped out at high water levels. At low water levels in the receiving watercourse, the runoff from the collecting area is mostly also facilitated by a free outflow at the pumping station by means of weir structures. These water management facilities form the backbone of the drainage system and have been designed and implemented in accordance with the needs of the land use. In the case of agricultural land use, the requirements for the extent, capacity and depth of drainage channels and drainage details (drainage, ditches, etc.) must be respected. The paper addresses the possibilities of using the retention capacity of the landscape using drainage systems as a network of drainage channels and drainage pumping stations, as foreseen in the forthcoming project for the use of channels as a source of water. Water could be stored in the channel system by interrupting runoff with small sluice gates. Another option is to provide water by pumping from the receiving channels when their flows increase. Both solutions have a common problem and that is the inflow of water into the systematic drainage and backflow in the piped systems. When water is pumped out of the receiving system, the reverse flow will be in the channels themselves. The paper analyses the hydraulic conditions and computational solution options for both methods of water retention in the landscape.

Key words: *drainage channel, flow capacity, pumping station, lowlands, flow conditions*

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Ecohydrological status of three intermitten flow Mediterranean rivers of Cyprus, Slovenia and Greece

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From the beginning of the 21st century the drought risk in the Mediterranean area is constantly increasing, as there are many irregularities in the variation of the precipitation and temperature. Precipitation and surface runoff decrease every year with consequences to the groundwater and reservoir storage. HBV model is applied to simulate the hydrologic response in the no-rain period of three intermittent flow river basins: a. the Tsiknias river basin (91.3 km² in size), in Greece, a basin of volcanic and sedimentary geology, b. Mavrokolybos river in Cyprus, a typical sedimentary and metamorphic geologic synthesis basin and c. Reka river, (29.7 km²), a karstic basin in Slovenia. The HBV model is used to estimate the runoff of the three rivers for the period 1990-2020 and the Temporary Rivers Ecological and Hydrological Status (TREHS) tool is used to classify the intermittent streams regime and status/degree of alteration based on metrics from hydrologically related data. A significant decrease of the annual flow of the examined rivers is observed and an increase in the frequency of extreme flood events. A shift to the Intermittent-Pools regime type is preferential harming therefore the ecological system and the storage potential of the downstream reservoirs.

Key words: *runoff-rainfall model, intermittent flow river, threshold temperature, river basin, flow calibration, dry season, low-flow, TREHS model, ponds, temporary rivers*

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Influence of Sand Particle Size on Liquid Limit of Sand Bentonite Mix

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A number of previous scientific studies on geo-environmental engineering state that suitable sand-bentonite mix can be used as an important component material for constructing landfill liner and cover system. Engineering and geotechnical properties of such mix are considerably influenced by its liquid limit which is the function of various parameters like quantity, texture, shape and size of the sand to be blended. Thus, extensive studies on these governing factors have been conducted by the previous researchers for in-depth understanding of different characteristics of sand-bentonite mix. However, the effect of sand particle size on its geotechnical behaviour was rarely explored in the literature. Main objective of current study is to investigate the influence of sand particle size on liquid limit of sand bentonite mix (LSBM). Twenty-four different mixes of bentonite clay with four various percentages of sand with six different particle sizes were experimented in laboratory to determine their liquid limits by Casagrande method. This study showed noticeable influence of sand particle size on LSBM for a particular mix proportion. Significant effect of bentonite quantity on LSBM with sand of specific size was also noted in the study. The LSBM considerably reduced when sand with larger particle size was used in the mixes of definite mass ratio. It also decreases with the increase in sand mass with certain particle size. These test observations are quite agreeable with that of the past researchers. However, the study did not investigate the effects of shape and texture of sand particles on LSBM.

Key words: *landfill liner; sand bentonite mix; liquid limit; particle size*

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SECTION

Outlook and perspectives of landscape conservation and design

Directions of ecological reconstruction of cities' green infrastructure

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In the ecological reconstruction of existing elements of green infrastructure and creation of new ones, we should focus on time-stable plant components. They retain their decorative properties with minimal human participation, supported by environmental dominance. An example of such a nature-oriented solution is the long-term program of the Government of Canada to select particularly frost-resistant rose cultivars with long and abundant flowering, resistant to adverse biotic and abiotic factors. At present, the most common technological solution in Ukraine for the arrangement of open urban areas is the use of a rolled lawn. The technology of its laying and caring for has already been worked out in detail. But it is important to keep in mind that this type of lawn requires a lot of effort, it is quite expensive. The author scientifically justifies an alternative type of lawn - juniper for the introduction into the green infrastructure of the city. It is proposed to do so with the help of cultivars of juniper horizontal (*Juniperus horizontalis*), in particular, the cultivar 'Prince of Wales', which was specially created by Canadian breeders for urban landscaping. This is a plastic plant resistant to drought, high and low temperatures, not requiring high agrophones. It does not require fertilization, mulching and aeration, emits the largest number of phytoncides per day, has high aesthetic expressiveness, forming new standards for urban landscape design. Based on the inventory of lawns and grasslands of the lawn type in Slobidsky district of Kharkiv, the author has found out that some of them are in unsatisfactory condition (36.478 m²), and might be reconstructed, using the above cultivar. Reconstruction work of 36.478 m² of lawn-type grasslands will cost 802.516 UAH annually for the local budget due to the creation of juniper lawns. At the same time, the use of a traditional rolled lawn will cost the local budget UAH 8244028 annually, i.e. approximately UAH 7.5 million more. For the full cycle, i.e 30 years, the savings will amount to UAH 225 million. The use of planting material that can grow at municipal enterprises of the city, engaged in landscaping, will significantly reduce the cost of technology to create juniper lawns.

Key words: *green infrastructure, lawn plantations, juniper lawn, urban landscape design, urban environment, landscaping.*

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Analysis of the interconnection of trees and sacral buildings of the Romanesque period

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Sacral buildings and the cultural and historical heritage of localities in Slovakia have a very strong connection and "Genia loci". Sacral buildings in Slovakia date back to the pre-Romanesque period (8th-9th centuries) and the Romanesque period (9th-13th centuries), when the first buildings and sites of spiritual significance of the Christian faith were created. The visual, aesthetic and cultural-social value of these buildings is also supported by woody plants, which have not only a functional character but also a symbolism related to regional religious architecture. The regional specifics of the localities are reflected in the sacral buildings but also in the assortment of used woody plants as well as their relation to the building, topography and cultural landscape. Significant buildings are Romanesque churches, chapels and rotundas located in western Slovakia, which were part of the already defunct Great Moravian Empire and represent the oldest preserved elements of the sacred architecture of the Christian faith. The symbolism of woody plants in the period of origin and in the period of reconstruction is manifested by quantitative but also qualitative features, which are the subject of the research task of the paper. The aim of the paper was to map and evaluate the intensity of interconnection, authenticity of woody plants and visual aspects of woody plants in the sacral buildings of the Romanesque period in western Slovakia. The subject of the research is the interconnection of trees and buildings together with visual and aesthetic features, which are influenced by the current climate change and the change in the use of the landscape and settlement. The researched localities were elements of religious and sacral architecture of western Slovakia, which are located in the urbanized space and cultural landscape. 7 buildings from the Romanesque period were evaluated and evaluated, of which 1 Rotunda - Skalica (1), 3 Rotundas rebuilt into a church - Dechtice (2), Križovany nad Dudváhom (3), Nitrianska Blatnica (4) and 3 churches - Dražovce (5), Kopčany (6), Nitra - Calvary (7). The results of the evaluation show that the connection of woody plants with the building was identified in five subjects (1, 2, 3, 4, 6). Significant symbolism associated with the spatial arrangement of trees supporting the character of the place and the effect of the phenomenon "Genius loci" was demonstrated in two subjects (2, 6). A significant effect was demonstrated especially in the second composition and originality of woody plants. However, in terms of vitality, health and aesthetic expression, the woody plants showed a worsened effect caused by climatic changes in the space, changes in the use of the space and mechanical damage by construction activities. However, woody plants still fulfill their function to a greater or lesser extent and help to preserve the identity of the cultural landscape and the historical significance of places.

Key words: *Trees, interconnection, cultural landscape, evaluation, Romanesque period*

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Accompanying greenery of roads in selected localities of vineyard areas of western Slovakia

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Western Slovakia is a relatively diverse cultural, especially agriculturally used country. Differences and specific features are manifested mainly in the species composition of woody plants as well as the proportionality of woody plants and the spatial arrangement. Species variability of woody plants in alley plantings is linked not only to the cultivation region but also to the symbolism associated with the specific cultivation and economic use of individual sites. The aim of the paper is to evaluate the species composition of trees of alley plantings in selected localities of the wine-growing type of the country, western Slovakia. The subject of the research task was field mapping and evaluation of alley tree plantings in selected localities of three wine-growing areas of South Slovakia's (1), Nitra's (2) and Small Carpathic (3). The evaluation focused on the composition of trees in alley plantings, age stage, vitality, orientation and topography of alleys, authenticity, interconnectedness and connection to the evaluated wine-growing area, climatic zone and the type of landscape of Slovakia. Evaluation of the interconnection of woody plants as a part of alley plantings and cultural landscape, the continuity of tree species with respect to the agro-climatic zoning of Slovakia distinguishes individual vineyard cultural areas and vineyard districts. For each wine-growing cultural area, the internal structure was evaluated, unique and characteristic for its region, location and justification. The research was focused on alley plantings in the extravillain, in the open country as well as in the contact zone bordering on selected model settlements. To objectify the measured data, several model areas were selected in individual wine-growing localities and accompanying alley plantings with a minimum number of 3 in each locality. The result of the research task was the evaluation of reference alley plantations, which document the presence and preservation of mostly fruit tree species (*Prunus cerasus L.*, *Juglans regia L.*, *Malus domestica L.*, *Prunus domestica L.*, *Prunus spinosa L.*, *Pyrus communis L.*). Despite the persistent pressure of change through anthropogenic activity in the country, these perform an important landscape-creating and aesthetic function, as well as other anti-erosion and protective functions in the country. Domestic deciduous trees were marginally identified (*Acer campestre L.*, *Acer platanoides L.*, *Quercus robur L.*, *Tilia cordata Mill.*, *Tilia platyphyllos Mill.*). Based on the results, we came to the conclusion that the presence of woody plants significantly affects the identity of the landscape and the colours of the viticultural type of cultural landscape. They perform a number of non-productive functions combined to varying degrees, with a predominance of protective, health-hygienic, cultural-social, protection and shelter of animals, part of the elements of ÚSES, a mosaic of landscape - landscape aesthetics. As an important phenomenon, they participate in the historical legacy of the past, they represent the character of the locality and the use of the cultural landscape.

Key words: *evaluation, cultural landscape, wine - growing area, woody plants, alley planting*

Acknowledgement: KEGA no. 024SPU-4/2019 Cultural and historical value of the vineyard landscape, development and current use

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Vineyard cultural landscape renewal options through landscape-architectural solutions

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The presented article thematically focuses on the issue of the vineyard cultural landscapes, as well as the search for their connection with the immediate surroundings, through the contemporary possibilities of various landscape-architectural solutions with the intention of preserving the idea of a sustainable part of the landscape. The paper discovers the hidden potential of this type of the landscape with regard to its cultural and social heritage and values. Vineyard areas are characteristic of the presence of accompanying small vineyard objects (in Slovak called "Hajloch's"), which are situated in different parts of the vineyard individually or in groups. The characteristic appearance of these typical buildings, during their development, was disturbed by the period of the 70's and 80's which brought a new architecture of different shapes and proportions into this structure. The changes also affected the gradual decline and loss of interest of some owners in the cultivation of vineyards. Some lands of the vineyard landscape are uncultivated, without basic care and functionally unused. Gradual decay, abandonment of vineyards and change of originally planted vine areas to building lands leads to the disruption and irreversible loss of the typical landscape character. The aim of the work is to return the function to these areas and thus prevent further decay and gradual damage of vineyards by human inactivity. The goal is to gain renewed interest, especially aimed at increasing the attractiveness of the site through the visual appeal of the environment through simple design solutions. Environmental responsibility, improving the condition and ensure the sustainability of these areas is the challenge. Their rediscovery through new procedures and approaches in the form of developing and supplementing new activities and support for greater community control and increased interest in this type of landscape through various nature-friendly alternatives for use, as well as guidance on future or current interventions, correction and masking of unsightly, less visually appealing structures or objects are also a big challenge for architects. As part of the research, in its initial stages through functional-spatial analyses, we identified potentially suitable areas that could be used for the community needs in the future. Within the vineyard landscape, there are different areas with different functions, so it is important to deal with the support of the orientation system, the direction of movement in the area and the indication of the conceptual solution of the program. The level of interventions and examples of solutions should serve to inspire and encourage interest in this type of landscape. Design solutions indicate the possibilities of the program, orientation, continuity, layering, masking, addition of elements, etc. The presented research asks rather than answers about the results and reveals and directly points out the terminology. It seeks to create discussion, not dogma. It is a process, a beginning, a systematic study and a basis that are directly leading to further in-depth examination of responses to initial interventions.

Key words: *sustainable management, community development, cultural landscapes, landscape architecture, design solutions, research by design, research for design*

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The role of local spatial development plans of Uście Gorlickie community in the protection of the South-Lesser Poland Protected Landscape Area

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The protected landscape area (PLA) is one of the nature conservation categories in Poland. It is protected for conservation of areas with distinct scenic values, which contain diversified ecosystems and are valuable, in particular, due to the possibility of satisfying tourist and recreational needs, or acting as an ecological corridor. At the same time, it is the weakest nature conservation category at the regional level. This is due the fact that there are no management documents prepared for it, and the possibility of implementing the conservation objectives, to a large extent, depends on the provisions of spatial planning documents prepared by local authorities. The aim of this study was to determine to what extent local spatial development plans (LSDPs) support the protection of PLA values. Uście Gorlickie community located entirely within the boundaries of South-Lesser Poland PLA was used as the research area. South-Lesser Poland PLA was established in 1997 and covers 3645 km² and 47 communities. It is the largest PLA located in the region. Uście Gorlickie is a rural community with an area of 287 km² and it is inhabited by 6843 people. The community's land use structure is dominated by forests (62%) and agricultural areas (34%). Due to the picturesque landscape and valuable historical objects, it is exposed to pressure from the development, including of tourist infrastructure and summer houses. The study was designed to answer the question: to what extent the community cares for and respect the landscape amenities in the spatial planning process. The study covered planning documents in force since the establishment of PLA. In total, 20 LSDPs were examined. The research focused on the provisions of LSDPs conducive to the implementation of active protection of forest, water and meadow ecosystems, e.g.: maintenance of landscape connectivity, creation and restoration of ecotone zones to increase biodiversity, afforestation of land less suitable for agricultural production, preservation of the mosaic of arable lands, hedgerows and shelters, increasing water retention, preservation of small water reservoirs. An important issue was also the protection of open areas from land use change (in particular leapfrog development), and the preservation of aesthetic and visual values of the landscape. The research revealed that the community currently has full coverage of LSDPs. In each of these plans, regardless of time of their creation and update, the detailed provisions of land development meets the principles of Lesser-Poland PLA protection. The research carried out showed that the Uście Gorlickie community is aware of the value of its natural resources and cares for them through appropriate provisions in the LSDPs. However, cultural values of the landscape, which should be equally important, were treated too generally. In 2020, Uście Gorlickie community began work on further amendments of LSDPs in this scope, which proves the need of more comprehensive approach to the protection of landscape values and character.

Key words: *Uście Gorlickie, spatial planning, nature conservation*

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Plastisphere – landscapes

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Growing exponentially production of synthetic materials, low recycling level and nearly 40 % of plastics devoted to disposable items led to the constantly increasing amount of plastics in the environment. This phenomenon is no longer unneglectable and their presence substantially changes landscapes and has numerous consequences on biota. One can observe the rivers changed in severs for wastes or the global ocean transformed into the sink for single-used products. During fragmentation, due to mechanical abrasion and UV radiation, the microplastic (< 5 mm) is formed. With decreasing volume, the available surface increases by a few orders of magnitude. The total surface of synthetic materials existing in the environment and available for biofilm is called Plastisphere. Sometimes it is compared even to the eight continent being an important new ecological niche. All in all, synthetic materials change gradually our Blue Planet into the Plastic one. In that perspective, it is crucial to reformulate the boundary conditions of landscape management. Moreover, an interdisciplinary approach is needed to deeply understand the behaviour of plastic in the natural environment: ageing, ecotoxicity, fate, transport, impact. This work shortly summarizes the 7 years of interdisciplinary work on (marine) microplastics and presents various case studies in a broad context. The Raman and FTIR spectroscopy is the characterization techniques enabling the identification of sampled debris. Furthermore, the quantitative approach is possible via the numerical description of surfaces that is based on SEM pictures. Among studied materials, one may find the microplastics from fishes, collected at high-seas, in the Arctic, exposed to natural weathering. The majority of samples contains microplastics from primary sources, thus peelings, scrubs, tyres, nurdles, etc. The secondary sources, slowly fragmenting, will be the source of plastic debris in years to come. The proposed holistic approach to tackle the problem includes monitoring strategies, sampling protocol, detailed physical and chemical characterization as well as the research on various impacts on biota and selected species. Finally, the list of diversified science engagement activities (popular lectures, Sail Training Activities, etc.) is to be shown together with the possible strategies to interact with the general public by, for instance, the photographic exhibition. This is necessary to provide a more sustainable future. The diversified “landscapes” of the Plastisphere have been documented in macro, micro and nanoscale.

Keywords: *Plastisphere, Microplastic, Nanoplastic, Raman Spectroscopy, Numerical Characterization, Surfaces*

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Analysis of the usability of sewage sludge for application in agricultural landscapes

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The use of sewage sludge in agriculture or in a landscape is now limited by current Slovak and European legislation. Strict rules are aimed at limiting the transfer of selected heavy metals and some synthetic substances into the soil or into surface and groundwater through the soil water cycle. The legislation is aimed only at direct land application of sewage sludge. However, sewage sludge is an important source of organic matter, nitrogen, phosphorus and other important micronutrients for plants. Application is also limited by complex permitting procedures, and in practice indirect application methods are used. These are based on pre-treatment or treatment of sewage sludge. This changes some of the properties of the sludge and results in a different name for the resulting material, which is no longer subject to the legislation on sewage sludge as biofertiliser, source of organic matter or compost. The conversion of sludge to ash by sewage sludge combustion is also being verified. The volume of sewage sludge produced in Slovakia is around 55 000 tonnes expressed as dry matter. In practice, at a normal solids content of about 35 %, this means three times that amount, which is about 30 kg per inhabitant per year. Direct land application is zero under the conditions in the legislation. Most of it is composted, a very small proportion is incinerated and some amount is landfilled. The sewage sludge produced is classified as 19 08 05 - Sludge from municipal waste water treatment in the current Waste Catalogue. This also causes problems for treatment with other biodegradable wastes. Waste management in the country is problematic. The paper reviews the assessment limits for the masses that will be generated after sludge treatment for use in the landscape, and the methods of transforming sewage sludge so that it is usable for a wide variety of landscape applications. The paper also addresses the necessary analytical methods that should improve the usability of sludge or simplify the application of methods for its use as a raw material for a usable product and suggestions for adapting legislation. The paper is based on the analysis of sludge from several urban wastewater treatment plants.

Key words: *sewage sludge, landscape, legislation, analytical methods, soil*

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SECTION

**Modern approaches for designing and maintaining urban
spaces**

The blue-green urban infrastructure as the way to mitigate the negative effects of climate change

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The significance and possibilities of nature-based urban infrastructure solutions use in order to limit the effects of climate change and air pollution as well as the rational management of water from precipitation is the aim of the study. Intensive urban development significantly impacts the environment and climate changes what may be reflected in the urban heat island effect, noise levels, air pollution, water management and adversely affects human health. Today, more than half of the world human population lives in cities, and projections indicate that the urban population could increase by up to about 60% by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2018). Despite occupying only 3% of the Earth's surface, the cities determine 60-80% of global energy consumption, 75% of carbon emissions and over 60% of natural resource use. The cities and their communities are constantly faced with the increasing scale of problems related to living conditions. Therefore, it is important and justified to perform the skilful use of nature-based solutions to improve the environment and the health of the inhabitants. The use of urban areas while promoting biological protection is one of the main challenges of the 21st century. The elements of the urban blue-green infrastructure, such as green walls, roofs, tracks or sustainable rainwater management systems, may perform a variety of functions, and thus provide many benefits. Nowadays, their importance in environmental protection processes and limiting the effects of climate change is emphasised. The health aspects (combating smog and urban heat island), economic aspects (inexpensive solutions with high benefits) and social aspects (better quality of life for people) are of equally importance. Despite its significant potential, the blue-green infrastructure is hardly used as a means to prevent climate change. In order to reduce the negative impact of urban development on the environment, green-blue infrastructure based on biodiversity and ecosystem services should be consciously integrated into the spatial planning and development of modern cities, as the tool with measurable economic and environmental benefits. It should become one of the basic elements of the strategy of mitigating the negative effects of climate change. The investments in that infrastructure are of long-term character, but provide a wide range of benefits.

Key words: *air pollution, modern city, municipal planning, nature-based urban infrastructure, sustainable rainwater management*

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Street models with green and blue infrastructure as a tool in planning a city resilient to climate change

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The issue of shaping green and blue street infrastructure is important in planning a city in the context of climate change. Streets constitute a significant percentage of paved surfaces, thus generating rainwater runoff, heating up and increasing the ambient temperature. The use of greenery (especially trees) and bioretention facilities can increase the retention and infiltration of rainwater at the site of precipitation, and thus reduce the amount of water flowing into the traditional rainwater sewage system, as well as improve the microclimate. The first streets with bioretention facilities were built in the USA, and then began to be used in Europe. Climate changes and new regulations on rainwater management justify the need for their implementation also in Poland. Planning and designing streets is a complex process, however, as it requires the coordination of many different elements, including natural and technical elements. Recognizing the need for changes in the approach to planning and designing the road network and taking into account the complexity of this process, the authors, developed street models showing the optimal arrangement of individual components of the road lane. In order to accomplish the task, the legal, spatial, and planning conditions were analysed, consultations were held with the Wrocław city units responsible for the implementation of road investments, administrators and owners of the underground technical infrastructure network, road industry designers, residents and NGOs. The models proposed by the authors relate to streets of access and local classes, which, due to the degree of design complexity and common use in local planning, could be standardized. The models show the location of bioretention facilities, high greenery, and individual technical elements of the road lanes and the underground technical infrastructure network. The model development was guided by the principle of rational land use and ensuring an optimal environmental effect, which was associated with designing the largest possible biologically active surface, at widths of the road lane. The models are an integral part of the Standards for planning and designing streets with green and blue infrastructure, which were introduced by the Order of the Mayor of Wrocław of March 20, 2020 as obligatory in the planning and design of the street network in the city.

Key words: *bioretention facilities, trees, sustainable water management, streets planning and design*

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The green streets application in limited urban space as an element of ecological connectivity system

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The main research goal was to propose transformation of the selected street into green one in order to complete the gap in the Warsaw Natural System. The project was carried out based on the principles formulated in the relevant literature and taking into account the available and limited urban space in the city of Warsaw, Poland. The first part of the work concentrate on the principles of creating green streets together with a catalogue of possible elements of green-blue infrastructure. These principles were compiled based on the leading literature including technical guidelines in the field of green streets adaptation of urban space to climate change. The authors focused on four key documents prepared for: Seattle, Portland, Philadelphia and Toronto as well as materials prepared by: EPA (Environmental Protection Agency in US) and WERF (Water Environment Research Foundation). Detailed rules for the transformation of the selected street are presented on the example of the Toronto Green Streets Technical Guidelines and supplemented with selected program points of the city of Portland and also Warsaw Green Council. The second part of the project presents a case study from the city of Warsaw. The goal was not only to transform the regular street into a more inhabitants-friendly and better adapted to climate change street, but above all to create a natural connectivity that would fill the gap in the Warsaw Natural System. The research area is located between two extensive green open spaces: Moczydło Park and Na Kole Woodland. There are several local streets and small squares in this area. The researched focused on deep analyses of various parameters collected during inventory as street structure, green cover (low and high vegetation), type and share of pavement, as well as planning guidelines from local master plans. The results of the analyses indicated that in order to achieve the goal, it will be optimal to transform Magistracka Street and Długomy Street, which form a compact line connecting green areas. The principles of selecting the street to be transformed were discussed successively, as well as the conducted natural, communication and social analyses. Based on the analyses, design guidelines were proposed along with the selection of appropriate elements from the catalogue of green and blue infrastructure. Next, the street was divided into relatively uniform sectors with a similar structure and share of green elements. Detailed solutions are presented in one of the sections along with the variety of nature base solutions, the selection of species and the solution of the communication system. The procedure allows to follow a comprehensive way of transforming an regular street into a natural sequence eliminating the problem of isolating green areas and maintaining natural connectivity in the city.

Key words: *green street, green infrastructure, urban natural system*

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The Experience of Using Parklets in Ukraine to Improve Public Urban Space

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Urban planners have been using new approaches to creating public spaces in city squares, streets, parks and other public places. Parklets is one of the modern approaches to improving the urban environment. The idea for their creation arose in San Francisco during the PARK(ing) Days program running in 2005. The parklet is an extension of the sidewalk aimed to increase the space and provide comfortable relax to people. It enables you to add some diversity to the monotonous lines of the city streets. It is often built instead of one or more parking spaces for cars on the side of the street, in the squares, near coffee shops and shopping malls. It is used to demonstrate how the area of one parking space can be used by many people concurrently. Parklets form mini public multifunctional spaces, which are equipped with seats. Tables, chairs, bicycle parking lots are installed here. Sometimes bowls of water for dogs are installed. Re-used materials are often used to create such objects which makes them useful from an environmental point of view. Evergreen shrubs, in particular species and cultivars of the genera *Juniperus*, *Taxus*, *Thuja*, *Chamaeciparus*, should be used for landscaping parklets to diversify the cityscapes and preserve their decorativeness in the winter. Deciduous shrubs and herbaceous perennials and annuals can be used as seasonal accents giving the place of temporary rest a unique look. Limited space requires an individual approach to the choice of range and the formation of compositions in parklets landscaping. In recent years, parklets have become very popular in Ukraine. City programs have been run and guidelines for the installation of these elements of urban development have been issued. According to these, everyone can initiate its installation. In Ukraine, they were first installed in Ivano-Frankivsk in 2015 by volunteers and members of the "Warm City" community. The construction is made of plywood with five hundred elements. The construction of the parklet made people think about how much space the cars take up in the urban space. Parklet has two seating areas: a large one for the whole company and a small one for several people to relax sitting on the floor, on benches or modules. There is a bicycle parking. Site. There used to be no bench on the street where the parklet was installed, so this public space will undoubtedly be popular with the city dwellers. In Kyiv, parklets were first introduced on Kontraktova Square within the framework of the PARK(ing) Days program. Activists seized a parking lot with sofas and sunbeds to show that the city belongs primarily to people, not cars. Currently, such street furniture appears in other cities of Ukraine: in Chernivtsi, Dnipro, Uzhhorod, Khmelnytsky and others. Creating such "pocket parks" in Ukraine is an urgent task. Such public spaces make an excellent way to locally change the urban landscape, revitalize and improve the urban environment.

Key words: *parklet, outdoor furniture, landscaping, public space, landscape design*

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University campus – Sustainable multifunctional component of the city urbanized area

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Universities and their campuses have been an important part of human culture for centuries and have a significant impact on the functioning and development of the urban landscape. Their quality is directly related to the quality of the surrounding environment. In cities, they are mostly situated on their borders, where they form a separate unit. At the edges, they represent a unique ecosystem and their impact on the functioning, sustainability and overall visual identity of the city is smaller compared to university campuses located in urbanized structures. They play their role more significantly and represent important spatial, social, economic and health functions of the city there. The presented contribution thematically focuses on the issue of university campuses as well as the search for their interconnection with urban structures with the intention of preserving the idea of a sustainable multifunctional part of the urbanized space. The literature review describes the issue of the terms campus and university campus as well as the dimensions of urban spaces. It focuses mainly on approaches to the creation of university campuses and their typology, classification into various concepts and also describes the historical development of university complexes in the context of urban structures. It monitors the role of the university campus as a catalyst for social and economic life in the city. It also deals with measuring the quality of university campuses through various methodological approaches and their effect on the surrounding environment. The subject of the work is also a research of various forms of university campuses and interpretation of results from measurements of various case study types through the methodology of multicriteria evaluation of the quality of public spaces, which was supplemented by directly related attributes to the issue of university campuses. Subsequently, it presents the basic contours of the strategic process, which can be observed in the field of the concept of university campuses at the level of the surrounding European countries and deals with specific examples. The methodology of multicriteria evaluation tries to understand all static and relatively immutable elements of the quality of university campuses over time. Only after a thorough analysis, putting the methodology tools into practice and detailed evaluation, we can name the individual problems of the area and choose the most appropriate solution to eliminate them and thus ensure the strengthening of the values of the city and the landscape. The result of the applied methodology and measurements is a set of recommendations for planning practice, which is the basis for a manual for the creation of university campuses with an emphasis on sustainability. Concerned with this issue, it is necessary to deal with existing methods, but also to bring new methods to the process of researching university campuses. One of them is the “Research by Design” method and its related methods (Case Study Research, Research for Design), on the basis of which we can derive a relevant result based on the design.

Key words: *green infrastructure, urban development, urban landscape, sustainability, multicriteria evaluation, research by design, research for design*

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SECTION

**Use of geo-information technology applications in the
landscape**

Using GIS technologies to assess the risk of erosion processes in landscapes in the context of climate change

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One of the global problems of humanity is the constant change of climate. Its manifestations affect primarily weather conditions: rising temperatures, increasing or decreasing rainfall and humidity, changes in the duration of the seasons, frequency of adverse weather events, etc. But there is an indirect reaction of the landscape to climate change, namely: expanding arid areas, reduction of forest landscapes areas, increasing erosion processes, etc. All these factors are very relevant for Ukraine because it is the temperate climate that is undergoing significant changes. Over the last half a century in eastern Ukraine the steppe landscape has shifted by almost 100 km to the north. This is reflected not only in climatic characteristics, but also in changes in vegetation, soil characteristics and agricultural specialization, reduced yields. If we add the removal of large areas due to increased erosion, the overall productivity of agriculture will decrease. Erosion processes are also directly related to the index of forest cover, which is constantly declining in Ukraine. Thus, the forest cover of the Carpathians has always been 95-98%. Now, due to a combination of climate change and intensive uncontrolled forest management, it has fallen to 55% in the highlands and to 15-20% in the foothills. Deforestation contributes to the active development of erosion processes. In the conditions of growing erosion danger in various landscapes, there is a question of its probable occurrence and development of measures to reduce negative consequences. According to the recommendations of the Intergovernmental Panel on Climate Change, the implementation of best practices, including "GIS support"¹, is promising. Modern GIS technologies allow us to analyse the orographic features of the landscape relatively quickly and in detail. We studied the processing of space images ASTER GDEM for 2019 with a resolution of 30 m, obtained from NASA Earthdata Search on the territory of several protected areas in the steppe landscape (National Nature Park "Dvorichansky"), forest-steppe landscape (National Nature Park "Slobozhansky") and mountain landscape (National Nature Park "Synevir"). TIN-models of relief have been built. On their basis we created derivative models, illustrating the magnitude of the landscape slopes and their exposure. Based on these models, the author outlined the boundaries of landscapes with the highest erosion hazard, which requires restrictions on operation and application of anti-erosion measures.

Key words: *landscape, erosion processes, climate change, GIS technologies, exposition, surface slope.*

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¹ Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Електронний ресурс]. – URL: <https://www.ipcc.ch/report/ar5/wg2/>

Landscape memory – application of program ArcGIS for mapping human activities

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Landscape of central Europe has been populated for centuries. During these times inhabitants left many traces of settlement, extraction, production, and other activities. Many of these relics are forgotten by people but landscape keeps their traces. It isn't necessary to search in ancient history, many of almost forgotten relics are traceable even in one century ago. Typical example of lost forgotten places is settlement in Šumava region, which was demolished after World War II. Today we can hardly exactly identify formation of these lost villages, but outlines of buildings, ways and other significant remains of settlement are still visible. These villages are often documented on old maps, photographs, pictures, postcards or in old chronicles. Due to technology, we are able combine actual maps and pictures of studied localities with preserved documents and reconstruct face of lost villages. Village Zhůří na Šumavě (Heidl) was chosen as example of lost settlement. This locality was lost in 50's of 20 century after displacement of population. The program ArcGIS was used for reconstruction of this settlement.

Key words: *GIS, landscape memory, lost places*

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