Doctoral Study Programme LANDSCAPE ENGINEERING – 2023/2024

Long-term effect of biochar application on nitrous oxide (N_2O) emissions from the agriculture used soil

Supervisor: doc. Ing. Ján Horák, PhD.
Workplace: Institute of Landscape Engineering
Field of study: Agriculture and landscaping
Study program: Landscape engineering
Form of study: daily/external

Thesis: Mitigation measures, the aim of which is to reduce greenhouse gas emissions, are becoming increasingly important, especially in relation to global policy in the field of climate change as well as EU legislation, including the strategic activities of the Slovak Republic, through which the Slovak Republic actively participates in fulfilling its obligations in the field of climate change. The ambitions of these legislative instruments and the achievement of sustainable agricultural intensification will only be possible if we know in detail the causes and processes that are responsible for the production of N_2O from the soil, as this will enable the implementation of the proposed mitigation measures in practice. Biochar is a product of thermal degradation of biomass rich in carbon. The so-called The "Terra Preta" concept is responsible for the recent increase in interest in biochar research, which is fueled by major global issues: climate change and the need to develop sustainable agricultural systems. Several positive impacts of soil-applied biochar on climate change mitigation have been reported (Lehmann, 2007) through soil carbon storage and reduction of greenhouse gas emissions from soil, improving soil quality and crop production. The aim of the dissertation is the assessment of the long-term impact of the application of biochar to the soil on nitrogen oxide (N_2O) emissions.

Rationale: Biochar added to cropland exerts some control over soil nitrogen (N) dynamics and has the potential to reduce N_2O emissions from soil. However, the evidence is not entirely conclusive, with some studies showing the opposite or no effect of added biochar on N_2O fluxes from soil to the atmosphere. So far, only a few multi-year field experiments investigating the effect of biochar on N_2O emissions have been carried out under real field conditions. It is therefore important to understand how biochar works in field conditions, as well as whether this effect is long-term or disappears after a certain time and another application of biochar is necessary. All potential mitigation measures to reduce N_2O from soil require careful consideration in terms of their ability to reduce N_2O emissions from soil while considering any financial, environmental consequences that may be associated with their incorporation into soil. For the purpose of long-term research on the impact of biochar on N_2O emissions, soil properties and crop yields, a field experiment was established in 2014 and continues up to now.

Financial coverage: VEGA 1/0116/21: Biochar as a tool for sustainable agriculture and APVV-21-0089: Biochar as a soil additive for sustainable agriculture in conditions of climate change.

The influence of climate change on the change of vegetation zones and area of agriculturally used land in Slovakia

Supervisor: doc. Ing. Ján Čimo, PhD.
Workplace: Institute of Landscape Engineering
Field of study: Agriculture and landscaping
Study program: Landscape engineering
Form of study: daily/external

Thesis: The issue of climate change is currently one of the frequently discussed issues. The effort of the entire society to adapt to these changes as well as the effort to mitigate ongoing climate changes is therefore gaining momentum. In the last decade, solving the problems of the impacts of climate change has moved from the scientific level to the social and political level, as well as to the level of practical applications. In this situation, coordination of resources and activities is necessary, especially at the national level.
Agriculture is significantly influenced by external environmental factors, especially soil-climate conditions. The method of land use depends not only on local natural conditions, but is influenced by several factors. The area of used agricultural land has been decreasing for a long time.
Agriculture reacts very sensitively to climate variability and weather extremes, such as droughts, strong storms and floods. Human activity has already affected chemical and physical atmospheric properties such as temperature, precipitation, carbon dioxide (CO_2) concentration, and ground-level ozone, and this trend is expected to continue. Crop production may benefit from a warmer climate, but increased incidence of drought, flooding and heat will present challenges for growers. Global climate change may make some regions unsuitable for growing crops. The aim of the dissertation is to evaluate and create current map outputs of vegetation zones and areas of agriculturally used land.

Rationale: In the conditions of Slovakia, the predicted global climate changes will mainly be reflected in changes in the temperature and moisture security of plant production, changes in phenological conditions, changes in the physical and chemical properties of soils, changes in wintering conditions and changes in the occurrence of diseases, pests and weeds.
So far, research works have been carried out that addressed changes in temperature conditions on agriculturally used land, where it was clearly demonstrated that the increase in the average air temperature resulted in the extension of the growing season in the entire territory of Slovakia. This change adversely affects crops in areas where summer heat already limits production, increases the intensity of evaporation from the soil and increases the possibility of severe drought. Up to now, changes in surface area in connection with climate change in Slovakia have not been processed in real terms. For the purposes of long-term research, it is therefore necessary to process and clearly define changes in the area of agriculturally used land.

Financial coverage: Submitted project KEGA Agrometeorological online laboratory, Demand-oriented research for sustainable and innovative food, Drive4SIFood, Topic 6: Agroclimatic regionalization as a model solution to the consequences of climate change in the complex of ecosystem services.

Water retention and nutrient recycling in amelioration channels for climate change adaptation and mitigation

Supervisor:	prof. Ing. Ľuboš Jurík, PhD.
Workplace:	Institute of Landscape Engineering
Field of study:	Agriculture and landscaping
Study program:	Landscape engineering
Form of study:	daily/external

Thesis: Amelioration canals in Slovakia and the surrounding countries were built primarily between 1955 and 1990. They were designed to supply water from sources to irrigation pumping stations or, conversely, to remove excess water from drainage systems. Their mission to achieve sustainable agricultural intensification has changed over time for two reasons. The method of agricultural plant and animal production has changed, and due to the influence of natural and anthropogenic processes, the landscape itself and the climate in our territory have also changed. Recently, a strategic document was created on the creation of adaptation and mitigation measures to mitigate the extreme effects of climate on the country. One of the measures is the creation of new reserves in the country.

The length of drainage and irrigation canals in Slovakia is 6883 km. Their retention capacity is used to a very limited extent, and most drainage open channels are mostly dry throughout the year. The new agriculture strategy until 2030 focuses precisely on the mentioned canals, and by retaining water in them, a significant supply of water could be created in the country.

The growth and development of cities, but above all municipalities, creates pressure on the surrounding areas and they grow almost inappropriately for the area distribution of hydromelioration structures. New streets come close to melioration canals and thus are often legally or unofficially recipients of rainwater from the inner city areas.

Rationale: The current state of the irrigation and drainage canals is unsatisfactory, and in several cases even dangerous, due to the minimal performance of maintenance in the last two decades. Therefore, it often happens that they are the subject of complaints from the inhabitants of municipalities and there are demands for the urgent cleaning of individual channels. The main reason for minimal maintenance is the lack of funds in the previous decades, which eventually reached the status of a necessary solution. The most important melioration channels are in the areas of the Danube lowland and the East Slovakian lowland.

In neighboring countries, studies evaluating the status, importance and need of hydromelioration facilities for the sustainability of agricultural production have been developed. The new price development of plant production commodities can have a fundamental effect on the economy and the benefits of using hydromelioration. New requirements for the country's biodiversity give a new meaning to the vegetation of reclamation constructions. We have to start where we used to be. Reclamations were requested and supported by crop producers.

The aim of the doctoral thesis will be to evaluate the new ecological, production and social functions of the built canals in the main areas and to propose a methodology to express their importance also in the field of solving the problem of extreme climatic events such as drought and floods and changed hydrological conditions of agriculturally used land and also their influence is constantly changing developing municipalities and their infrastructure.

Financial coverage: Project financed by Norwegian grants: Improvement of the state of the wetland of the NPR Klátovské rameno in the area of SKUEV0075 and upcoming APVV and VEGA projects from 2024.

Influence of microplastics on heavy soils hydrophysical characteristics of the East Slovak lowland.

Supervisor:	Ing. Branislav Kandra, PhD.
Workplace:	Institute of Hydrology SAV (detached workplace in Michalovce).
Field of study:	Agriculture and landscaping
Study program:	Landscape engineering
Form of study:	daily/external

Thesis: At present, more than 350 million tons of plastics are produced annually in the world. Only a small part of this volume is recycled and the rest remains in the natural environment, including the soil. These are different types of polymers, which disintegrate to form particles of different sizes and shapes. In the case of microplastics, these are particles in the order of micrometers, which have been shown to have a negative effect on living organisms and the environment. Contamination of the soil environment by microplastics can occur in various ways, such as mulching, sewage sludge, irrigation with untreated water, floods, etc. The content of microplastics in the soil affects its physical, chemical and biological properties. The aim of the dissertation will be to analyze the influence of selected types of microplastics on the hydrophysical properties of soils (soil texture, volumetric and specific gravity of soil, porosity, hydraulic conductivity, moisture retention curves, etc.) representing the East Slovak Lowland.

Rationale: Soils contaminated with microplastics show changes in physical, chemical, and biological properties. Despite this, few studies have addressed the environmental impact of microplastics on the soil. Some of them pointed out how the presence of microplastics can modify soil's physical properties. The research will be carried out in laboratory conditions on soil samples representative of East Slovak Lowland. The soil sampling will be carried out in such a way that the selected localities cover typical soil types in the lowland. The benefit of the work will be not only the expansion of knowledge about the degree of influence of various microplastics on the hydrophysical characteristics of soils but also a better understanding of the change in hydrological conditions in such contaminated soils.

Financial coverage:
The detached workplace of the IH SAS in Michalovce has high-quality equipment for the research of soil hydrophysics in both laboratory and field conditions. The dissertation will be supported by the project VEGA 2/0044/20.

Water flow overgrowth by aquatic vegetation and impact of the vegetation on stream flow conditions

Supervisor: Ing. Yvetta Velísková, PhD.
Workplace: Institute of Hydrology SAS
Field of study: Agriculture and landscaping
Study program: Landscape engineering
Form of study: daily

Thesis: Water flow overgrowth by aquatic vegetation is a very common problem of surface streams, especially in flat areas. Preconditions for its growth is mainly in the so-called growing season. Aquatic vegetation reduces the flow profile of watercourses, deforms the velocity profile, and thus also affects the transport processes in the surface watercourse. In addition, the surroundings of watercourses in the lowlands are often heavily farmed with the using of fertilizers. Then, it results an increase in the concentration of nutrients in the watercourse that support the growth of aquatic vegetation. The content of the dissertation will be the quantification of the influence of aquatic vegetation on the flow conditions in the surface stream. The influence of nutrient content and temperature on the overgrowth rate of watercourse beds will also be analyzed and quantified. A prerequisite for the successful achievement of the goals is a thorough research of the current state of knowledge of the given issue, a theoretical analysis of possible methodological procedures, performance of field measurements at a selected location using modern instrumentation as well as the application of statistical analysis methods.

Rationale: As a result of global warming, temperatures are rising also in the territory of the Slovak Republic; summers are warmer and winters are milder. For this reason, the year-round occurrence of aquatic vegetation in streams flowing through the warmest regions of Slovakia is no exception, i.e. The Danubian, East Slovak and Záhorská Lowlands. Lowland streams mostly flow through important agricultural areas of the country, where fertilizers are expected to come into contact with water streams. Thus, fertilizers can greatly affect water quality and promote the growth of aquatic vegetation. Another factor influencing the occurrence of aquatic vegetation is the small slope of water courses in lowland areas, and the resulting small flow velocity in the stream. As a result of these facts, there is a settling of carried particles in the stream, an increase of the bottom sediments thickness, and thus an improvement of the conditions for the growth of aquatic vegetation, which, on the other hand, then affects the flow conditions in the stream. When designing and assessing measures that should lead to the improvement of water resources management in the country, it is necessary to know and be able to solve this problem of streams flowing through flat, often heavily agriculturally used territory.

Financial coverage: VEGA 2/0028/23 - "Changes in hydrodynamic and morphological indicators of the river bed as a result of overgrowing with aquatic vegetation in lowland areas". Institute of Hydrology SAS owns instrumentation for field experiments, as well as software equipment for numerical modeling.

Quantification of the impact of water retention measures on the hydrological regime of urban basins

Supervisor: doc. Ing. Marek Sokáč, PhD.
Faculty: FZKI SPU Nitra
Workplace: Institute of Landscape Engineering
Academic year: 2023/2024
Form of study: daily/external
Study program: Landscape engineering
Field of study: Agriculture and landscaping
External educational institution: Institute of Hydrology, Slovak Academy of Sciences

Thesis:

The thesis will be focused on green infrastructure impact on urbanized catchment runoff regime and its quantification, as well as the possible use of rainwater as an additional source of service water in the urbanized area. Another goal will be a survey of the impact of the climatic changes on the hydrological regime of the urban catchment as well as analysis of the extent to which it is possible to mitigate the impacts of extreme climatic events (resulting from anticipated climate changes) in urbanized areas by implementing green infrastructure. This goal is related to the question of whether, in addition to green infrastructure, it is necessary to consider other measures in order to achieve the balance and efficiency of investments with regard to their effect. As part of the research, it is assumed that several case studies will be developed on real urbanized areas in the Slovak Republic.

Rationale:

One of the promising technologies for the reduction and retention of runoff in urbanized areas is green infrastructure (e.g. green roofs), which, thanks to its hydrological function in the urbanized area, has a great ability to reduce and retain precipitation runoff. This ability can be one of the decisive factors for the sustainable development of cities, especially in connection with the predicted climate change. However, a problematic point remains the possible extent of green infrastructure application in the typical conditions of Slovak cities and the real impacts of the application of this technology on the runoff regime of an urbanized watershed, or other environmental impacts (e.g. reduction of the number and volume of discharged water, reduction of the so-called "heat island" effect, etc.).

Financial coverage:

The Institute of Hydrology of the SAS owns instrumentation for field experiments, as well as software equipment for numerical modelling. The focus of the work will be on numerical modelling of alternatives and their impacts, field research will be supported by submitted projects within the grant scheme Water4All, APVV, respectively of the proposed VEGA grant.

Assessing the condition and dynamics of agricultural landscapes and soils using spatial modelling and remote sensing.

Supervisor:	Mgr. Andrej Halabuk, PhD.
Workplace:	Institute of Landscape Ecology SAS
Field of study:	Agriculture and landscaping
Study program:	Landscape engineering
Form of study:	daily/external

Thesis: This topic focuses on the development and testing of innovative approaches for assessing the status and dynamics of agricultural landscapes using spatial modeling of diverse geodata, including remote sensing products. The main purpose of the work will be to examine the condition and dynamics of agricultural landscapes, with a focus on the evaluation of their most important natural resource - soil - and the methods of its management. The dissertation topic will be examined within the framework of the implementation of multiple research activities of ongoing projects (ESA, COST, Horizon Europe) in a larger international collaboration with the potential of exchanges and short-term internships.

Motivation: The basic prerequisite for sustainable use of agricultural landscapes is the spatial characterisation of the state of its key natural resource - soil - and knowledge of how to manage it in the long term. Remote sensing, including satellite-based platforms, currently provides unique opportunities for effective mapping of soil conditions at different spatial scales, as well as for detecting and monitoring soil management practices. A number of satellite-based indicators reflecting soil properties are currently being developed, including products assessing the degradation and heterogeneity of agricultural soils. However, for a wider application of these techniques, targeted research in real conditions is necessary to more accurately characterise their possibilities and limitations for their implementation in application practice.

Finantial support: Ongoing projects supported by the European Space Agency (ESA), Horizon Europe, submitted COST action

Vegetation phenology assessment using combination of terrestrial and remote sensing observations

Supervisor: RNDr. Ľuboš Halada, CSc.
Workplace: Institute of Landscape Ecology SAS
Field of study: Agriculture and landscaping
Study program: Landscape engineering
Form of study: daily/external

Thesis: Recently, especially in connection with climate change, the study of vegetation phenology and its seasonal and year-on-year changes has become increasingly important. With technological development, the possibilities of studying phenology have also expanded - in addition to the classical methods of field vegetation research, methods of terrestrial automatic registration of phenological processes of vegetation and methods of studying the phenology of the earth's surface using remote sensing (RS) are being developed. The PhD student will focus on the development of consistent approaches and methods for the study of vegetation phenology of various ecosystems by ground research and remote sensing methods. The subject of the work will be the study of plant phenology in various ecosystems through phenological observations, analysis of phenocamera photos and processing of RS data in relation to the course of meteorological parameters. The proposed approaches and methods will be applied at the topical level at existing permanent research sites and at the regional level in the selected region. The thesis will also evaluate the advantages and disadvantages of individual approaches and their synergy.

Rationale: The climate and the course of the weather have a significant effect on plant phenology, therefore phenological data can be used to assess climate change and its intensity. This is an extremely topical subject these days. However, phenological data can be also used for other purposes, such as assessment of soil moisture and moisture balance, assessment of drought intensity and its impacts, or prediction of flowering time of allergenic plant species. Therefore, the need and usefulness of phenological measurements is coming to the fore. However, there are still few studies that integrate new approaches with "classical" field methods and use their combination to extend the possibilities of studying plant phenological expressions.

Financial coverage: project VEGA 0115 Long-term changes of atmospheric pollution and their impact to ecosystems; Horizon 2020 project eLTER PLUS