

Serbian Society of Soil Science
University of Belgrade, Faculty of Agriculture

BOOK OF ABSTRACTS

3rd International and 15th National Congress

SOILS FOR FUTURE UNDER GLOBAL CHALLENGES



21–24 September 2021
Sokobanja, Serbia

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FOREWORD

The Serbian Society of Soil Science continues its tradition of hosting conferences, which is one of its primary activities. It organized the 3rd International and 15th National Congress – Soils for Future Under Global Challenges in the International Decade of Soils 2015–2024, collaborating with the University of Belgrade Faculty of Agriculture and under the auspices of the Ministry of Education, Science and Technological Development of the Republic of Serbia, along with sponsors and numerous contributors of papers. Namely, the International Union of Soil Sciences (IUSS) proclaimed the International Decade of Soils 2015-2024. In the Vienna Soil Declaration of 7 December 2015, IUSS recognized the key roles soils play in addressing major resource, environmental, health and social challenges currently facing humanity.

Due to the COVID-19 pandemic, the Congress was held as an online event, in combination with limited physical presence of international and domestic participants who observed the prescribed epidemiological measures and recommendations of the Serbian Government.

The topics of the Congress were grouped into the following four sessions: (i) Soil fundamentals, (ii) Soil-water-plant-atmosphere continuum, (iii) Soil degradation and soil and water conservation, and (iv) Soil and water future socio-economic pathways. The thematic areas were selected to support the distinct efforts of agriculture, and humankind in general, to deal with current resource, environmental, health and social issues.

Growing population pressures, industrialization and intensive use of soil exhaust natural resources and limit the performance of soil functions, such as biomass production, water purification, carbon sequestration, and the like. The additional impacts of climate change, land use changes and the above mentioned global changes affect the ability of soils to regenerate and even lead to degradation. The future capacity of soils to support life on Earth is in question.

A number of conferences on soil and global changes have been held worldwide over the past several years. Continuing these efforts, we need to keep in mind that the study of soils has changed rapidly. Previously, soil science was seen as supporting agriculture and forestry, and justified by increased soil productivity. However, the focus has recently expanded considerably. Soil science is now a major component of each environmental science course, given that soil plays a key role in elementary natural cycles. Soil pollution is also extremely important, often more persistent than air or water pollution. The impacts of global changes on soils are viewed from a much broader perspective than only several decades ago. However, despite the interest in new fields, the agricultural imperative must not be forgotten. Agriculture remains the main economic purpose of the use of soils and hunger is certainly among the most serious potential disasters set off by global changes.

Ninety-eight contributions were accepted for presentation at the Congress and included in this Book of Abstracts. They reflect the outcomes of the most recent research in 17 countries worldwide. The contributions were prepared by more than 320 authors and co-authors. This shows that most of the presentations were a result of teamwork, which not only guarantees a comprehensive approach, but also quality.

Seven distinguished domestic and international professors and scientists prepared the keynote speeches. The submitted papers are available on the website of the Serbian Society

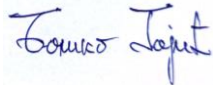
of Soil Science (<https://congress.sdpz.rs>). The contributions contained in this Book of Abstracts have been reviewed by international peers.

An excursion completed the program and content of the Congress. It included showing of four soil profiles of the dominant soil types in the Sokobanja area, including Calcomelanosol, Brownized Calcomelanosol, Calcocambisol and Vertisol, under different land uses (native meadow, devastated native pasture, native forest and intensive apple orchard).

It is our wish to see all the positive outcomes of the Congress implemented in due course, along with recommendations of scientists and professionals. This would fulfil the objective of the Congress in the best possible way. The permanent legacy of the Congress should be the inclusion of soil in the core of policies that support environmental protection and sustainable development.

In closing, I wish to express once again my sincerest gratitude to all who contributed to the publication of this Book of Abstracts.

September 2021 in Sokobanja

A handwritten signature in blue ink, reading "Boško Gajić". The signature is written in a cursive style with a blue background behind the text.

Prof. Dr. Boško Gajić

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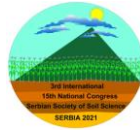
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Soils for Future under Global Challenges

PLENARY LECTURES



Soils for Future under Global Challenges

CONTENT AND SCOPE OF PEDOLOGICAL RESEARCH FOR FOREST SITES MAPPING

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Abstract

Forest sites mapping is an innovative concept of forest division in Serbia, although this method has been used in Western Europe for decades. It is based on the selection of types of forest sites, which represent homogeneous units in terms of ecological and production characteristics, which are exposed to approximately the same hazards and risks and to which the same management treatments are applied. The mapping method itself is based on the overlap of digitized thematic maps: geological, pedological, maps of climatic conditions (temperature, precipitation, etc.), maps of soil properties (water and nutrient regime), geomorphological maps, maps of current and potential vegetation, etc. Given the sectoral inconsistency and the unavailability of appropriate digital maps, the primary sites mapping method used in Germany could not be implemented in Serbia. Having in mind the insufficient study of forest soils in Serbia, an integral and at the same time the most important part of the methodology, are detailed pedological studies. The methodology used was developed by the joint work of a team of Serbian and German experts and included existing available maps and data, but also the results of detailed field studies of land, sites and vegetation. In forest soils, in contrast to agricultural lands, physical properties (depth, mechanical composition, porosity, etc.) are of much greater importance for the survival of tree species, because the water regime of the soil depends on these characteristics. Serbia is a medium-forested country, with a forest cover of 29.1%, which is close to the world but significantly below the European forest cover (46%). In the next 70 to 100 years, great changes are expected in Serbia, primarily in the composition of tree species and the appearance of new types of forests. Forest ecosystems have adapted and survived in changing climatic conditions for millions of years. However, what is a big problem today is the speed and intensity of climate change. Forests simply do not have enough time to adapt, which leads to their drying and decay. Precisely one of the basic goals of forest sites mapping is to create a database on water balance and soil nutrient regime. Based on soil characteristics, it is possible to predict changes in accordance with projected estimates of climate change (temperature and precipitation). This method of assessment gives the possibility of timely selection of species whose ecological conditions correspond to the projected climate conditions. The characteristics of the soil of an area are placed in the center of the division, because the properties of the soil, primarily its ability to retain water, have been singled out as a key factor in the survival of a certain type of vegetation. The trend of climate change in our country, according to most scenarios, is changing in the direction of increasing the average annual temperature, uneven distribution of precipitation during the year, more frequent and longer dry periods and more. This concept has been implemented and tested in the area of the Mt. Boranja massif located in NW Serbia. The study covered the belt of hilly and mountain beech forests, on three geological substrates: granodiorite, phyllite and limestone.

Keywords: Mapping, Mt. Boranja, Soil, Vegetation, Site types



Soils for Future under Global Challenges

SOIL QUALITY FOR PLUM PRODUCTION IN THE ŠUMADIJA REGION

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Abstract

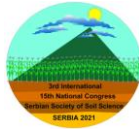
Domestic or European plum (*Prunus domestica* L.) is a leading fruit species in Serbia and traditionally one of the most important fruit tree species in Serbia. It can even be said that plum is one of the symbols of Serbia (a national brand). With 558 930 t of plum production, Serbia was ranked second in Europe and third in the world in 2019, having been surpassed only by China and Romania. The total plum growing surface in Serbia amounted to 72,316 ha in 2019, listing Serbia the topmost plum grower in Europe. Plum trees are grown across the whole territory of Serbia, but the most important areas of plum cultivation are region of Šumadija and western Serbia (Valjevo, Kraljevo, Kragujevac, Osečina, Prokuplje and Čačak).

The subject of the study was fertility of agricultural soils under plum orchards, as well as the soils planned for the establishment of new orchards. In the Šumadija region, growing of plum orchards is mainly situated at higher altitudes, with suitable exposure of the slopes and soils with generally lower characteristics. A total of 106 soil samples were taken at two depths (0-30 and 30-60 cm) and analyzed. Parameters of soil fertility (main chemical properties), the content of available DTPA (Diethylenetriamine pentaacetate) extractable microelements (Fe, Mn, Zn, Cu) and the content of available B (H₂O extraction) were examined in the scope of the research.

Soil quality in the studied area is primarily determined by the processes of pedogenesis, as well as cultivation practices, i.e. the applied system of cultivation and fertilization. On average, an acidic soil reaction with a very low content of carbonates and readily available phosphorus was found in all the analyzed samples. The content of humus, total nitrogen and readily available potassium were at a moderate level. According to the research results, 71% of the total number of samples were carbonate-free in the surface and sub-surface soil layers. Regarding the content of readily available phosphorus, at both investigated depths 0-30 and 30-60 cm, most of the examined soil samples (66% and 91%) had a very low content of available phosphorus (<4 mg per 100 g). Availability of microelements (copper, iron and manganese) was at the satisfactory level in all studied soils. The analysis of available boron (B) showed insufficient boron supply in 70% of the analyzed samples, especially in deeper soil layers. Similar situation, although less pronounced, was found in the analysis of available zinc content in deeper soil layers.

Šumadija has great natural potentials, which provide a solid basis for future development and regional leadership in the production of traditional plum products. Variations in plum production results and soil quality confirms that the optimization of water-air regime and soil fertility are among main requirements to achieve full yield potential.

Keywords: Šumadija region, plum production, soil quality



Soils for Future under Global Challenges

CLIMATE CHANGE AS THE DRIVING FORCE BEHIND THE INTENSIFICATION OF AGRICULTURAL LAND USE

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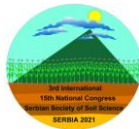
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Abstract

If one looks at the global climate changes, it becomes clear that previously intensively used agricultural regions will be severely affected by climate change due to rising temperatures and falling amounts of precipitation. The supply of agricultural products from the affected regions, such as the Mediterranean region, Ukraine, but also Australia and the Midwest of the USA will therefore be influenced to a large extent by the conditions of climate change. On the other hand, as recent studies show, there are favorable locations such as in southern Brazil or, in contrast to Australia, New Zealand. The FAO anticipates an increase in annual demand of one billion tonnes, to around 3.5 billion tonnes, of plant products by the mid-2030^s. The roughly 15% increase in the world's population from 7.9 billion now to over 9.7 billion by 2050 will be a powerful factor in food distribution. In addition, the daily energy intake will increase from the current 2831 kcal (FAOSTAT) to 3130 kcal in 2050. As a result of the supply shortage and increases in energy prices, animal feed, fertilizers and fuels are also becoming more expensive and thus the costs of agricultural production are higher. Rising revenues due to rising market prices for agricultural products are thus partially offset by the increasing cost pressure. Increasing variability in the climate leads to higher uncertainties in production, which will result in greater risks/failures and thus higher costs. Global climate change will intensify agricultural production methods in Europe. Rising land and lease prices are forcing land users to optimize their profits. Extensive use methods such as "organic farming" or "extensive suckler cow husbandry" will unfortunately have the "disadvantage" of intensive processing companies and/or well-run "intensive farms" and "investors" when leasing land or acquiring new agricultural land. With the expected intensification, however, it is more important that those requirements such as product quality, traceability and "sustainability" are adequately taken into account. The quality of the production process itself is therefore increasingly in the foreground and farmers react accordingly. The currently high environmental standards must not be reset, even though the market development caused by climate change poses a risk. To prevent this from happening, ecological and other goals for agricultural land use must increasingly be set and implemented in a binding manner in agricultural regions.

Keywords: agricultural production, climate change, sustainability, population growth, intensification of land use



Soils for Future under Global Challenges

INTEGRATED WATER RESOURCES MANAGEMENT: EVOLUTION OF CONCEPT, PRINCIPLES AND APPROACHES

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Abstract

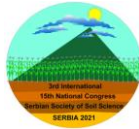
Water management plays an important role in society since it intersects different technical, economic, technological, environmental and societal sectors, and policy issues. The difficulties of properly approaching this topic are increasing since management solutions should be seen in the context of continuously altering spatial-temporal scenarios generated by climate variability and change, population growth and migration, land use transformation and socio-economic concerns. Therefore, the unceasing challenge is to embrace, in a comprehensive way, the numerous technical, socio-economic and environmental factors, institutional settings and stakeholders' interests interplaying throughout the scales in the water management process.

The concept of integrated water resources management has been evaluating since the end of the last Century with the aim to consider new challenges related to climate change, land/water/energy/food insecurity and a common need to achieve the sustainable development goals. Hence, the water management in agriculture should be seen in the same perspective of integration and consider different interests of stakeholders across administrative, hydrological and management scales. Moreover, the concept of nexus should be introduced as a core strategy to deal with the global challenges. In this context, it is fundamental the resolution of conflicts between sectors in order to balance the “demand vs. availability” equation, the “agronomy-engineering” symbiosis to optimize the performance of irrigation networks, and the adoption of the eco-efficiency approach as a modern management concept and indicator of sustainable water use.

The concept of eco-efficiency provides the opportunity to upgrade the set of common indicators for the assessment of agricultural water management and to introduce a new conceptual frame that evaluates the performance of irrigation schemes and adopted management practices in a more comprehensive way. Eco-efficiency has not a specific spatial and temporal context. Instead, it is a concept of global interest and it is spreading independently across the hydrological scales and water management units. The eco-efficiency aims to bridge the gap towards the effective implementation of integrated water management at different scales since it contemplates, in a consistent and rational way, technical, environmental, social and economic aspects of water management.

A case study is presented to demonstrate how the eco-efficiency approach was applied over a large irrigation district located in Puglia region (Southern Italy). The performance of agricultural water management at the irrigation scheme scale is assessed by means of three fundamental indicators: 1) the resources exploitation index (i.e. the ratio between water withdrawal and availability at the hydrological unit scale); 2) the overall technical (engineering and agronomic) agricultural water management efficiency (i.e. the multiplier of efficiencies of each management stage across the water supply chain), and 3) the eco-efficiency expressed as (i) the ratio between the overall economic benefit and total water withdrawal for agricultural sector and (ii) the ratio between the overall economic benefit and total CO₂ emissions caused by irrigation and complementary agronomic practices.

Keywords: Water management, irrigation, eco-efficiency, sustainability



Soils for Future under Global Challenges

USE OF TRACERS IN SOIL EROSION RESEARCH – APPROACHES AND CHALLENGES

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Abstract

Soil erosion is a significant environmental problem worldwide. The need to obtain accurate and reliable soil erosion intensity to identify erosion-prone areas and select appropriate soil conservation options is emphasized. Besides several existing monitoring and modelling methods (e.g., (R)USLE-based models, erosion pins, etc.), the potential of nuclear techniques to study erosion has been recognized. The fallout radionuclides (FRNs): artificial ^{137}Cs and $^{239+240}\text{Pu}$, natural geogenic ^{210}Pb and natural cosmogenic ^7Be , are used as soil redistribution tracers. The FRN techniques can provide information on soil redistribution rates at different temporal (from a few days up to a period of ~100 years) and spatial (from plot to large catchment) scales and the soil redistribution patterns. There are different available models for calculating soil redistribution rates based on FRN inventories, i.e., conversion models. This contribution reviews current models for soil erosion assessment, discussing the advantages and limitations of traditional and conversion approaches and highlighting the specific needs for their further improvement. It also summarizes soil erosion assessments obtained by conversion models in studies conducted in Serbia in areas significantly affected by soil erosion.

Keywords: soil redistribution, nuclear techniques, erosion models, radiotracers



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CHEMOMETRICS FOR SOIL POLLUTION MONITORING

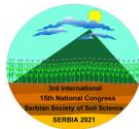
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Abstract

Chemometrics, defined as mathematics and statistics in chemistry, has been widely present in soil pollution monitoring studies for quite some time. The chemometric approach incorporates a large number of algorithms and models. In most cases, chemometric methods are used to optimize the measurement procedures to gather soil pollution monitoring data or to elucidate qualitative and quantitative relationships within these data, which may be quite complex and be overlooked when using classical methodologies. Soil pollution monitoring involves the processes of sampling and analyzing specific toxic pollutants, such as heavy metal(oid)s, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), petroleum hydrocarbons, pesticides, and radionuclides. With the help of modern analytical techniques, the spatial and temporal changes in concentrations of these pollutants usually generate a vast amount of data. In order to achieve meaningful soil monitoring, both sampling/analysis and data assessment procedures must be carefully planned and performed. This often includes factorial design strategies for experiment optimization. Two factorial designs, one used for screening the selected parameters and the other used for their optimization, are usually used together. Alternatively, a sequential optimization may be made by applying the Simplex algorithm. On the other hand, among the most used chemometric methods for soil pollution monitoring data evaluation, two groups can be distinguished: supervised and unsupervised pattern recognition methods. In supervised methods, input and output data are known, and the primary goal is to find the relationship between inputs and outputs. These methods are most often used in classification so that the soil sample joins an already defined group. There is also an application in regression, where the input values of soil contaminant predict the output result. This group includes partial least squares regression (PLS), discriminant analysis (DA), artificial neural network (ANN), support vector machines (SVM). In unsupervised methods, no prior knowledge of any relationship in the soil pollution dataset is required. The aim is to identify the underlying structure within the dataset. These methods are commonly used for dimensionality reduction and exploratory analysis. The following unsupervised methods are frequently used: principal component analysis (PCA), cluster analysis (CA), positive matrix factorization (PMF), and Kohonen self-organizing maps (SOM). In addition to the chemometric tools mentioned above, geographic information system (GIS) analysis protocols, such as spatial autocorrelation, inverse distance weighted interpolation, and kriging, are unavoidable in soil pollution monitoring.

Keywords: multivariate, classification, GIS, trace, PCA, source.



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ASSESSMENT OF SPATIAL VARIABILITY OF SOIL CONTAMINATION: USE OF A MULTI-SCALE APPROACH ASSOCIATING PROXIMAL SENSORS, PEDOLOGICAL AND MICROSCOPICAL INVESTIGATIONS

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Abstract

As recently stated by the Food and Agriculture Organization of the United Nations in the Status of the World's Soil Resources Report (SWSR), soil pollution represents one of the main soil threats affecting global soils and the ecosystem services provided by them. In this environmental context, there is an urgent need to achieve fast identification of spatial variability of environmental contaminants aimed to precision sampling of polluted materials, as well as for targeted prevention and remediation strategies. Remote sensing techniques are known to be alternative and efficient remote and noncontacted detection methods for mapping and monitoring of various soil contaminants; they are essential tools, well-suited for surveying large areas, and monitoring soil contamination at a high temporal and spatial interval. Despite the wide progress made in remote sensing of soils during the last decades, several crucial problems (such as presence of vegetation, etc.) still affect and limit their use for soil contamination monitoring. Proximal soil sensors (PSS) are efficient and accurate techniques for measuring within-field variations of soil properties at a very fine spatial scale, and then even more required in environmental studies (i.e., soil pollution, land degradation processes, etc.). PSS are non-invasive, time- and cost-efficient, then they offer many advantages over the traditional techniques (such as no use of environmental polluting acids and little need for sample preparation, simplicity of use and easy portability, wide dynamic range of elemental quantification, etc.). Then, PSS enables to overcome the limitation of spatially scarce data, to achieve a fast identification of the spatial variability of contamination and to apply targeted prevention and remediation strategies. PSS are coupled with a Global Positioning System (GPS) receiver enabling georeferentiation of the acquired parameters and processing of soil maps. Nevertheless, many questions arise about the choice of the most efficient method to be adopted for preliminary assessment of spatial variability of unknown anthropogenic soil contaminants or physically degraded soils, since the available sensors differ for the detected physical parameters. Therefore, the most appropriate PSS depends on and must be related to natural and anthropogenic soil variability, source of contamination (diffuse or hot spot), type of soil and contaminants, etc. Anyway, the successive phase of direct pedological investigation in area of interest (such as those where anomalies of signal are identified) cannot be neglected due to the need to assess nature, distribution and possible fate of contaminants over the depth. A detailed soil investigation along the soil profile at field, microscopical and sub-microscopical scale provides the identification of significant layers, morphological characteristics of materials and sediments, peculiar pedo-features supplying insight into the fate of contaminants in soils. Hence, an overview on several case studies over Italian environments will be presented to show a multi-sensors approach, pedology supported, for the assessment of detailed knowledge on the spatial variability of soil contamination by PTE in agricultural and industrial sites of southern Italy formerly interested by anthropogenic contamination.

Keywords: soil pollution, anthropogenic contamination, agricultural and industrial soils



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SECTION 1: SOIL FUNDAMENTALS



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ELEMENTAL COMPOSITION OF HUMIC ACIDS ISOLATED FROM CHERNOZEMS, VERTISOLS, REGOSOLS, PLANOSOLS AND HISTOSOLS

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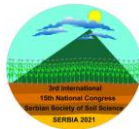
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Abstract

Humic substances, including humic acids (HAs), are the most abundant fractions of soil organic matter. Their composition, structure and properties, determined by soil formation conditions, can be used as indicators of pedogenetic processes. In this study, elemental composition as very important part of HAs characterization was determined for humic acids isolated from the soils of Serbia developed under different pedogenetic conditions (Chernozem (CH), Smonica/Vertisol (VR), Rendzina/Regosol (RG), Pseudoglej/Planosol (PL) and Prelazni treset/Histosol (HI)) and related to soil properties and origin. Soil samples were collected at 0 to 15-30 cm depth. Soil texture, organic C (soil organic matter for HI), and pH were determined by common methods. HA samples were isolated using a modified IHSS method. The C, H, and N contents of HA samples were determined using elemental analyzer (CHNS 628, LECO Corporation, USA) after drying the samples over P₂O₅ under vacuum. Their percentages were calculated on the ash-free basis. The content was obtained as the difference. The ash content was determined by a dry combustion method. The C/N, O/C, H/C and O/H atomic ratios were used as indicators of variations in HA properties as a function of HA origin. Internal oxidation degree (ω) was calculated by the equation: $\omega = (2O+3N-H)/C$, where: O, N, H and C are element contents (atomic %). Elemental compositions of investigated HAs fall within the range of average values reported for soil HAs. According to the humification degree obtained, HAs studied are ranged as follows: CH>VR>RG>HI>PL. Both correlations done (H/C versus O/C and H versus C) separate HAs in three groups: CH and VR - the most dehydrogenated and demethylated, i.e. the most stable; RG - the most oxidated; and HI and PL - the most hydrogenated. HAs elemental composition is related to soil organic C and pH, but not related to soil clay. Internal oxidation degree is used as an indicator of plant residue humification progress. Positive ω values point out well drained soils with prevailing oxidizing conditions and negative values reflect anaerobic soil conditions. Internal oxidation degree values are obviously lower in hydromorphic HI and PL HAs compared to terrestrial RG, CH and VR HAs, but positive values indicate predominance of aerobic under anaerobic conditions in surface layer of hydromorphic soils. Results obtained in this study are in agreement with the literature data, indicating characteristics of HAs as particularly dependant on environmental conditions.

Keywords: humic acids elemental composition, atomic ratio, internal oxidation degree, environmental conditions



HOLOCENE RUBIFICATION IN BOREAL AND SUBBORIAL SOILS OF WESTERN SIBERIA: A PEDOGEOGRAPHICAL ANALYSIS

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Abstract

Rubification is a rather widespread pedogenic process, related the release of iron from primary minerals to the form of free iron oxides, that appear as thin coatings on the surfaces of quartz grains, maintaining the reddish color of soil (from 2.5 to 10 YR). It is generally believed, that rubification mainly occurs under conditions of warm climate in humid or wet-dry tropics. At the same time, recent studies performed for the territories of Central Europe with temperate climate and rather low annual temperatures have revealed that reddish soils and subsoils appear within the areas covered with Late Pleistocene sandy deposits and this feature generally is not always relict. Our recent soil-geographical and soil-geomorphological studies performed within the Western Siberia, gave us an opportunity to suggest that Holocene rubification is also evident for this vast region, though this process is rather local and requires specific environmental conditions. We have examined soils with uncommon reddish color in a range of boreal and subboreal ecotones, including hemiboreal forests subzone, middle and northern taiga. For all studied sites soils with signs of rubification occupied comparatively small areas within the territories covered with Late Pleistocene and early Holocene aeolian sands and for most of the examined locations they were characteristic for the lower parts of catenas. According to the results of analytical studies it was shown that reddish soils differ from background Arenosols and Podzols by the higher content of Fe, specific chromatic properties and the presence of Fe-oxides. Our preliminary examination has two important consequences. First of all, the obtained results suggest the possibility of Holocene rubification even under conditions of cold continental climate with low annual temperatures (up to -6°C) and long seasonal freezing. Secondly, they support the concept, suggested by Hirsch (2019), that development of such soils requires specific topographical-hydrological conditions with allochthonous iron input.

Keywords: rubification, Western Siberia, Holocene, soil catena

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TEMPERATURE AND MOISTURE REGIMES OF RENDZINA SOILS IN SERBIA ACCORDING TO THE USDA SOIL TAXONOMY SYSTEM

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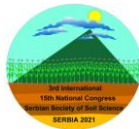
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Abstract

Soil moisture and temperature regimes are diagnostic characteristics used for higher categories of the USDA Soil Taxonomy System. The first step of Rendzina soil classification in Serbia according to this international system is to determine the soil temperature and moisture regime classes. As measured soil moisture and temperature data of the investigated Rendzina profiles were missing, the Rendzina soil temperature and moisture regimes were estimated based on climate data (30 years) – monthly and annual air temperature and precipitation, and potential evapotranspiration. Six weather stations were selected: at Novi Sad for the northern, Valjevo for the western, Belgrade for the central, Negotin for the eastern, Sjenica for the south-western and Niš for the south-eastern regions of Serbia. The estimated mean annual soil temperature in the study areas ranged from 8.7 to 14.5 °C, and the mean summer and winter soil temperatures differed by 18.6-21.4 °C. The Rendzina soils in all the study areas match the criteria for the mesic soil temperature regime. Precipitation becomes greater than potential evapotranspiration and water recharge begins in September in Sjenica and in October in the other areas. Potential evapotranspiration exceeds precipitation and utilization starts in March (Novi Sad, Belgrade and Niš) or April (Valjevo, Sjenica and Niš). The amount of moisture stored in the soil during this period, plus precipitation, is believed to be sufficient to support potential evapotranspiration and avoid significant water deficits in western and south-western Serbia (Valjevo and Sjenica). Utilization is expected to exceed recharge plus precipitation in all other areas, causing soil water deficit to begin in April in Belgrade and in May in Novi Sad, Negotin and Niš. Therefore, the soils in the western and south-western areas match the criteria for the udic soil moisture regime, whereas soils in the other areas (central, east and southeast) correspond to the ustic soil moisture regime. Possibly lower water infiltration and available water capacity, caused by geomorphological and physical properties of Rendzina soils, can increase water deficits further, but precipitation in the summer months is hopefully sufficient to avoid long periods of dry days. Separation of Rendzina soils in Serbia into two soil moisture regimes, udic and ustic, could affect their classification at higher taxonomic levels according to the Soil Taxonomy System.

Keywords: Mesic soil temperature regime, Udic soil moisture regime, Ustic soil moisture regime



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CORRELATION BETWEEN RANKER SOIL TYPE OF NATIONAL CLASSIFICATION SYSTEM AND LEPTOSOLS REFERENCE SOIL GROUP OF WORLD REFERENCE BASE FOR SOIL RESOURCES – THEORETICAL APPROACH

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Abstract

National soil classification system (NSCS) used in Serbia is based on the principles of genetic classification. It utilizes the concept of genetic soil horizons. The world reference base (WRB) for soil resources is based on soil properties defined in terms of diagnostic horizons, diagnostic properties, and diagnostic materials, which to the greatest extent possible should be measurable and observable in the field. The difference between genetic vs. diagnostic horizons creates an obstacle in correlation of soil types from NSCS with reference soil groups (RSG's) of WRB for soil resources, whereas the advantage in this work is that most of the soil names of national system correlate to the revised legend of the Soil Map of the World which is an forerunner of WRB for soil resources.

This work aims to compare Ranker soil type of NSCS with corresponding RSG from WRB for soil resources, namely with Leptosols, as they have been reported in Serbia and abroad, as an appropriate reference soil group. The comparison was conducted on the base of qualitative and semi-quantitative information collected from the literature and experience of the authors – theoretical approach. It was conducted in two ways: a) Leptosols vs. Rankers, meaning which Leptosols of WRB for soil resources are Rankers in NSCS, and b) Rankers vs. Leptosols, meaning which Rankers of NSCS are Leptosols in WRB.

The conclusion of our work is that Leptosols RSG can correspond to Rankers in NSCS, but some WRB Leptosols are also Lithosols, Technosols, soils of Subaquatic soil order, Eugleys, Humogleys, Peat Soils, Rendzinas, Kalkomelanosols, Eutric and Dystric Cambisols, whereas Gypsic Leptosols can not be classified according to NSCS. Observing in different direction, the results show that Ranker Soils could be also part of some other RSG with Leptic principal qualifier, such as Andosols, Phaeozems, Umbrisols, Cambisols, and Regosols. This work represents a small contribution to soil science in Serbia as WRB is comprehensive classification system that enables accommodation of NSCS's for communication at the international level.

Keywords: National soil classification, WRB, Rankers, Leptosols



PEDO–EXCEL: A SIMPLE EXCEL TOOL/DATABASE TO PREPARE AND ELABORATE SOIL PROFILE DATA

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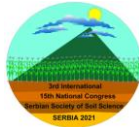
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Abstract

Soil investigations in pedology are often made of four different stages: a) preliminary stage, b) on-field soil research, c) laboratory (analytical) research and d) data elaboration. Depending on the aim of soil investigations each of these stages can last for a different amount of time. On-field soil research is the central part of soil surveys. It consists of soil profile excavation, description of soil profiles and collection of soil samples. Experienced soil scientists can vast a lot of time in description of soil ectomorphological and endomorphological properties, whereas un-experienced soil scientists move often fastly over this stage to soil sampling. The description of soil profile is of the essential importance in soil surveys and a huge number of soil information can be collected while describing soil profiles. Soil description is often done manually by filling soil forms, but it is somewhere digitized. It is also a time–consuming job how to prepare those data for the further elaborations, often how to make them digitized. Another important issue in front of the researcher is how to present a large number of soil characteristics and to elaborated data in fast and efficient manner. Therefore, this necessity of being most efficient in soil data elaboration has forced us to prepare a simple Excel based tool to fastly retype and elaborate soil profile data. Pedo–Excel is based on FAO Guideline for soil description. General information, soil formation factors, and soil description headings with the different number of soil characteristics are offered to the users in drop down menus, which are specific for each soil characteristics. The user simply inserts collected data by choosing them from the menus. By this manner, the users can fill the columns for all soil horizons/layers and re-type the data for whole soil profile(s). Soil characteristics are provided with their full names and used abbreviations. Data elaboration in Pedo–Excel starts with the simple choice which of the soil characteristics should be presented in our work, by simple choosing of "1" (yes) or "0" (no) into the column next to the characteristic. The result of this choice is an Excel table with chosen soil characteristics. Each soil sheet presents one soil profile with up to ten soil horizons/layers. Almost all soil characteristics presented in FAO Guideline are part of the Pedo–Excel. Pedo–Excel is a simple, user friendly, and time efficient tool for elaboration of huge series of soil profile data collected during soil surveys.

Keywords: soil description, pedology, soil morphology, MS Excel tool, data elaboration



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MICROBIOLOGICAL AND CHEMICAL PROPERTIES OF AGRICULTURAL SOILS IN SOUTH-WESTERN SERBIA

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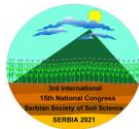
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Abstract

Soil management is important to all agricultural systems and the reduction of soil degradation is a base to sustain future plants production. Physical and chemical characteristics of soil are the most important properties that affect the number of microorganisms, especially pH and organic matter content. The aim of this investigation was to examine microbiological and basic chemical properties of agricultural soils in the south-western part of Serbia. Soil samples from 62 localities of agricultural soil were taken aseptically from a depth of 0-25 cm. Based on the pH value tested soils are acidic, between 3.96 and 6.20, with medium content of humus. Results of this study showed that the presence of microorganisms in the tested soil samples is influenced by numerous factors and that each soil provides different conditions for life of microbes. The total number of microorganisms in soil samples varied from 18 to 122×10^6 , the number of free-living nitrogen-fixers from 17 to 95×10^5 and fungi in the range from 3 to 55×10^4 per one gram of absolutely dry soil.

Keywords: soil, microorganisms, free-living nitrogen-fixers, fungi



BACTERIAL COMMUNITIES IN ACIDIC SOILS

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Abstract

Acidification is one of the main types of soil degradation in Serbia, as a result of excessive use of mineral fertilization, pollution, as well as reduction of soil organic matter. Increased soil acidity directly affects plant nutrition and food productivity, at the same time leading to biodiversity changes. Bacterial diversity in soil is recognized as the main pillar of soil quality, ecosystem stability, climate change resilience, and represents an important element of sustainable agriculture. The diversity and abundance of bacteria in soil are strongly related to various abiotic factors, particularly to soil pH as one of the major determinants shaping their community structure. The main objective of the research was to access the bacterial community in agricultural acid soils using metagenomic approach. Soil samples were taken at three locations: cornfield near Zaječar (Eastern Serbia), apple and raspberry orchards near Čačak, (Central Serbia). The representative samples were subjected to sequencing of V3 and V4 regions of 16S rRNA gene using Illumina[®] MiSeq[™]. Besides microbiome, physico-chemical analyses were performed, including mechanical composition, adsorptive complex properties, and basic parameters of soil fertility. Soil samples from Čačak have strongly acidic reaction, belonging to class of clay loam with a significant share of powder fraction. Soil from Zaječar is heavy clay with 48,80% of the clay fraction, and middle acidic reaction. Cation exchange capacity (CEC) is the middle level, and saturation of the adsorptive complex with base cations is weak in raspberry orchard soil, while soil under apple and corn showed high levels of CEC and middle saturation of adsorptive complex with base cations. Soil from apple orchard is characterized by low humus content and low content of available phosphorous (P), and middle P content in the raspberry orchard and cornfield. Available K content was similar for three analyzed fields (35,60-37,90 mg/100g). In all of the studied soils, the most abundant phyla were *Firmicutes*, *Proteobacteria*, and *Actinobacteria* (each above 20%), which are the usual predominant phyla in the fertile soil. *Proteobacteria* composition showed differences between the soil samples, with higher share of *Enterobacteriales* in cornfield soil. Acid soil from Zaječar had 4.89% abundance of *Chloroflexi*, while the soils from Čačak included six additional phyla besides *Chloroflexi* (with more than 1% abundance), indicating significantly higher biodiversity. After the three most common phyla, *Acidobacteria* were predominantly abundant, and the presence of these oligotrophic taxa is characteristic of less fertile soil. *Actinobacteria* are mainly related to neutral or alkaline soil, but in recent decade acidotolerant *Actinobacteria* are being highlighted in terms of maintaining ecosystem balance, and raise of pH. The composition of bacterial community showed some similarities between tested soils, with differences within their microbiome that can be attributed to mechanical composition and agronomic practice.

Keywords: acidic soil, bacterial community, metagenomic analysis, 16S DNA



CHARACTERISTICS OF SOIL QUALITY OF THE SURČIN MUNICIPALITY AND ITS SIGNIFICANCE FOR PLANT PRODUCTION

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Abstract

In order to assess the general suitability for plant production, in the period from June to October 2019, tests of physical and chemical properties of 275 composite soil samples were conducted in the area of Petrovčić and Progar, Surčin municipality, to a depth of 30 cm. According to the distribution of soil regarding the values of hygroscopic moisture, it was determined that the highest number of examined samples is in the range of 2 to 6%, and the lowest - in the range of 6 to 10%. The presence of total sand, dust and clay fractions in the analyzed soil samples indicates a relatively uniform textural composition. 94-98% of the examined soil samples belong to the textural class of light clays that have an unfavorable ratio of total sand/clay fractions, in which the clay fraction prevails. According to the values of substitutional acidity (pH in H₂O), the largest number of samples has a strongly acid (<4.5) to acid (4.51-5.50) reaction. The supply of total nitrogen ranges from 0.12 to 0.20% in 80-85% of samples, and in 2-4% of samples the values of this parameter are from 0.05 to 0.12%. The supply of humus in 97-98% of the samples is in the range of 1.50 to 4.00%, which is a property of slightly clayier soils. In addition, in connection with the examined water-physical properties, it is considered that soils with higher content of clay particles and humus have higher values of hygroscopic moisture, because clay and humus have a large active surface and can bind a large number of water vapor molecules from the air. The content of easily available phosphorus in 91% of samples from the area of Petrovčić is very low, while in the area of Progar 50% of samples have a very low, 18% - low and 16% - medium content of the tested element. In the area of Petrovčić, the largest number of samples (54%) is with medium content of easily available potassium, while 25% of samples have high content. Soil samples, taken in the area of Progar, are richer in potassium, so the largest number of samples is highly provided (43%) and medium provided (37%) with available potassium. The values of adsorptive soil complex parameters indicate the largest number of samples with moderately saturated and moderately unsaturated base cations (85-87%). Most samples have a very low Na⁺ content, which ranges from 0-1 meq/l, resulting in very low calculated SAR values. The values of SAR, calculated on the basis of analyzed content of Na⁺, Ca²⁺ and Mg²⁺, indicate that the risk of salinization is very low. The obtained results indicate that the examined soils of Petrovčić and Progar, Surčin Municipality, are suitable for intensive field production, especially wheat, corn and sunflower. Nevertheless, low pH values indicate an adequate application of limestone.

Keywords: Surčin municipality, soil, physical properties, chemical properties, plant production



WATER-PHYSICAL, MECHANICAL AND CHEMICAL PROPERTIES OF ARIC REGOSOLS FROM POVARDARIE REGION

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Abstract

The development of agriculture in the Republic of North Macedonia is related to the analysis of soil-climatic conditions in the given area and the knowledge of the biological properties of different varieties and substrates and the specifics of the production technology. Mistakes made in the application of these measures, due to ignorance of the soils, can be catastrophic, because they require large investments with action for a long period. The paper presents the results of the research of the soils used as vineyards. Conditions for formation of soils and their properties for the soil types Aric Regosol. Particular emphasis is placed on the fertility of the soils and the measures to be taken for successful planting and growing vineyards and accurate selection of grapevine rootstock. The average values by depth of all surveyed soil samples are as follows: Humus content is highest at a depth of 0-30 cm max. (2.09%) and min. (1.07%). Total nitrogen is from (0.119% to 0.068%). The reaction of the soil correlates with the content of carbonates pH-H₂O (8.02-8.07) and carbonates from (8.28 to 18.96%). The percentage of active CaCO₃ is from 3.73 to 8.61%. Soils are well supplied with phosphorus (13.32 to 29.29 mg/100 g soil) and potassium from 20.99 to 45.55 mg/100 g soil. In terms of physical properties, the soils of the Povardarie region have favourable total porosity. The porosity of 0-30 cm and 30-50 cm is significant and is 54-55%. Upon reviewing of the content of separate fractions, it can be noticed that the coarse content (fragments > 2 mm) is represented below 10.0%, which means the soils are poorly skeletoidal. Clay fraction (< 0,002 mm) is dominant between the fractions of the soil separates, with 33.88 % in average. The soils of the Povardarie region are very vulnerable to different types of land degradation. In conditions of increased negative effects of climate change, soil erosion is one of the most dangerous and devastating types of land degradation. For this reason, special attention should be paid to this type of land degradation in viticulture production due to the fact that in many cases the producers apply some practices which intensify the process of soil erosion: e.g. the downslope orientation of vineyards, furrow irrigation, cultivation of the vineyards when the soil is not ready, i.e. too dry or too wet, for cultivation. For that purpose, 25 soil profiles were excavated for this research in the wider area.

Keywords: Aric Regosols, particle size distribution, chemical properties, measures to improve soil productivity.



TOXIC ELEMENTS IN SOILS FROM VLASINA REGION

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Abstract

The widespread contamination of soil with toxic elements represents currently one of the most severe environmental problems that can seriously affect environmental quality and human health. In this research, the optimized three-step sequential extraction procedure for the fractionation of micro- and macroelements, proposed by Commission of European Communities of reference (BCR) has been applied to the soils from Vlasina region. The following fractions were extracted: exchangeable, reducible – bound to iron/manganese oxides, and oxidizable – bound to organic matter and sulfides. Element concentrations in the extracts obtained at each step were determined using an Inductively Coupled Plasma - Atomic Emission Spectrometer iCAP-6500 Duo. Magnetic susceptibility (MS) was measured using magnetic susceptibility meter SM30. The index of geoaccumulation (Igeo) has been applied to assess trace elements distribution and contamination in studied soils.

An assessment of toxic element levels in the studied soils is made by comparing the total contents of the extracted elements with the limit values determined by Serbian Regulation ("Official Gazette of RS", No. 30/2018). An increased content of the following elements was observed: Cu in the soil sample near the Tegošnička river (Dobroviš), V in the soil sample near Vlasina (in front of the water intake, below the Pusta river), as well as Co in several locations. The values of copper and vanadium content are slightly higher than the maximum limits defined by the Serbian Regulation. These elements are predominantly bound in the residual, immobile, fourth fraction (about 50% of extracted Cu, 70% V and 50% Co), which indicates that the aforementioned elements do not represent a danger for the environment. Taking into account the rock composition characteristic for this region, the binding site of microelements such as Co, Ni, Cr, and Cu could be shales, as well as ultrabasites-basites and serpentinites. Considering that, due to the influence of complex geological substrate, it is possible to expect increased cobalt contents in the soil and its origin is natural. Given that the highest percentage of Co is bounded in immobile fractions, there is no risk of environmental contamination. The results of magnetic susceptibility measurements confirm the hypothesis of the dominant natural (geogenic) origin of the elements from the metamorphic rocks that predominate in this area.

Keywords: contamination, extraction, fractionation, magnetic susceptibility



STRUCTURAL STABILITY OF AGGREGATES OF VERTISOLS DEPENDING ON THE CONTENT OF ORGANIC MATTER, CLAY AND CALCIUM CARBONATE

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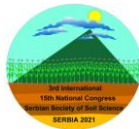
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Abstract

Soil structure affects the physical, chemical and biological processes of the soil. It affects the accessibility of air, water and nutrients, as well as resistance to erosion, germination rate and penetration of root systems into the soil. A total of 6 pedological profiles were opened at the sites on the territory of the city of Smederevo, three of which belong to the subtype Carbonate Vertisol, and three to the subtype Non-carbonate Vertisol. The purpose of the study was to determine the influence of clay, humus and CaCO₃ on the structural stability of aggregates. Samples were taken from genetic horizons A, AC, and C from three depths in the semi-disturbed state for analysis of structural stability of aggregates (wet sieving). Soil samples were used to determine clay, humus and CaCO₃. The results of wet sieving of the soil show that the agronomically most important aggregates of 8000-2000 μm are the highest in the surface horizon, while with the increase of depth their share decreases. The fraction 2000-250 μm has the largest share in the AC horizon, while the fractions 250-53 μm and <53 μm have the highest values in the C horizon. In the case of aggregates 8000-2000 μm, differences were found in the A horizons of the Carbonate Vertisol (average 35.30), in the case of non-carbonate (average 13.44), while there were no differences with the depth of the profile. The fraction 2000-250 μm differs in AC horizons and amounts for carbonate (average 65.76%) while in Non-carbonate Vertisol (average 70.08%). No differences were found in the fractions 250-53 μm and <53 μm. The mean weight diameter (MWD) results indicate that the structural stability of aggregates is higher in the surface horizon in Carbonate Vertisol (2.31), compared to Non-carbonate Vertisol (1.28), while with increased depth there were no differences. The MWD were mostly influenced by the content of CaCO₃, which was proven by a very strong correlation $r = 0.82$ between the content of CaCO₃ and MWD, while the content of clay and humus did not show a correlation with the MWD index. Although low, concentrations of CaCO₃ in Carbonate Vertisol significantly affected the MWD index, which was proved not only by the correlation but also by the difference of MWD in the A horizon of Vertisol in favor of Carbonate Vertisol.

Keywords: Structure, Vertisols, clay, organic matter, CaCO₃



Soils for Future under Global Challenges

CONTENT OF AVAILABLE CALCIUM AND MAGNESIUM IN THE VERTISOLS OF THE PČINJA DISTRICT

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Abstract

This paper represents the results of the content study of available Ca and Mg, in the vertisol type soils found in the Pčinja District area, using the method of ion chromatography. Ten different pedologic profiles of vertisols were created, seven profiles of carbonate vertisol subtype and three profiles of non-carbonate vertisols subtype. Fieldwork research was carried out in the Pčinja District - GPS space positioning of all profiles, along with coordinates, altitude and terrain exposition.

The results obtained by analysis indicate that the carbonate vertisols are the richest in calcium, the average content being 20.57 g/kg, varying between 17.3 and 24.2 g/kg.

The average content of calcium in non-carbonate vertisols is 12.45 g/kg, varying between 6.1 and 22.9 g/kg. The correlation analysis has shown that there is a complete correlation between the pH value and the content of Ca ($r=0.80$) and Mg ($r=0.96$).

The research results show that non-carbonate vertisols of the Pčinja District contain more magnesium than carbonate vertisols from the same area. The results also indicate that the humus-accumulating horizon of non-carbonate vertisols contains the average of 1.41 g/kg of Mg, varying between 0.67 and 2.9 g/kg. The average content of Mg in the humus-accumulating horizon of carbonate vertisols is 1.27 g/kg, varying between 0.83 and 2.20 g/kg.

The magnesium content in the majority of tested profiles of both carbonate and non-carbonate vertisols tends to rise with the depth of the profile.

Keywords: Vertisols, Pčinja District, carbonate, non-carbonate, calcium, magnesium



Soils for Future under Global Challenges

ANDOSOLS AND PROBLEMS OF THEIR CLASSIFICATION IN CONDITIONS OF SLOVAKIA

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Abstract

Andosols occurring and developed in Slovakian conditions are evaluated in this contribution. Andosols are situated on volcanic rocks, mainly on pyroclastic deposits with vitric components and existence of allophanes. More typical Andosols have been identified under forest, slightly developed Andosols occur also on agricultural land (situated mostly on greenland near the forest land) with often existing of andic cambic B horizon (as a part of cambic B horizon) and could be classified as Andic Cambisols. These soils are represented by very dark brown to black colour (Munsell colour value and chroma 10YR 2/1 – 2/2 when moist), humous (more than 10 % of soil organic carbon – SOC), and acid to very acid (pH/KCl values range between 4.0 – 5.0). Soil colour is strongly influenced by high content of organic matter and parent material. Andic properties may be identified using the sodium fluoride field test of Fieldes and Perrott. A pH in NaF of 9.5 and more indicates allophane. According to several previous and latest international and national classification systems andic properties include mostly: $A_{lox} + \frac{1}{2}Fe_{ox}$ value of 2.0 percent or more; and a bulk density of 0.90 g/cm³ or less; and a phosphate retention of 85 percent or more (WRB 2014); and less than 25 percent (by mass) organic carbon; and increasing amount of allophanes with depth; and thixotropy (field test for soil material change under pressure or by rubbing, from a plastic solid into a liquefied stage and back into the solid condition). However, above described properties are not always sufficient for identification of typical Andosols. According to our additional experimental results as well as $\Delta pH \leq 0.5$ (difference between pH/H₂O and pH/KCl), content of $Fe_d > 2\%$ (iron in dithionite extract), resp. $Fe_{ox}/Fe_d < 0.6$, $A_{lox} + \frac{1}{2}Fe_{ox} > 3\%$ (oxalate extractable aluminium and iron), content of organic phosphorus 1500–2000 mg/kg, content of $N_t > 0.8\%$, $C_{HA} : C_{FA} < 1$ and C : N ratio between 12–15 (moder humus form), Q_6^4 between 3.5–4, bulk density less than 0.9 g/cm³ are characteristic for these soils. Concerning the indicators of ¹³C NMR spectrum is also very important a percentual distribution of aliphatic (Calif) and aromatic carbon (Car). It was determined that the aliphatic carbon is predominant (Calif/Car ratio is running mostly in the range 1.3–1.8) in evaluated soils. In addition, existence of melanic A horizon was not determined according to our obtained results but fulvic A horizon has been found in all described soils in Slovakia where melanic index was higher than 1.7 (WRB 2014). These additional indicators could help better to classify typical Andosols in heterogenous soil cover.

Keywords: Andosols, soil classification, andic properties, thixotropy, Slovakia



DIVERSITY AND PLANT GROWTH PROMOTING POTENTIAL OF RHIZOBIA ISOLATED FROM ROOT NODULES OF *LOTUS CORNICULATUS* L.

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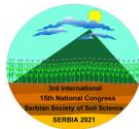
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Abstract

Lotus corniculatus L. is a perennial legume plant that enters into a symbiotic relationship with nitrogen-fixing bacteria belonging to *Mesorhizobium* genus by forming root nodules within which the nitrogen fixation occurs. This plant is a valuable forage crop of high nutritional value that thrives on less fertile and/or degraded soils. The analysis of bacterial diversity within the root nodules of *Lotus corniculatus* is indispensable, as nitrogen fixing bacteria could be used to promote the growth of this valuable plant. The aim of this research was to isolate and determine endophytic rhizobial bacteria from root nodules of *Lotus corniculatus* L. and to evaluate their plant growth promoting (PGP) characteristics. Nitrogen fixation efficiency as well as the ability of isolates to produce PGP substances such as indole-3-acetic acid (IAA), siderophores and to solubilise inorganic phosphates was evaluated *in vitro*. In addition, antifungal activity of isolates against three fungi belonging to *Fusarium* genus (*F. oxysporum*, *F. graminearum* and *F. proliferatum*), as well the ability to produce hydrolytic enzymes, such as amylase, cellulase, protease and pectinase was tested *in vitro*. In total, 72 bacterial isolates from the root nodules of *Lotus corniculatus* L. sampled on the territory of Republic of Serbia were isolated. Nodulation test showed that 58 isolates could infect the plant and form nodules on *Lotus corniculatus* L. roots. Overall, 50 isolates produced IAA in a wide range of concentrations, 29 isolates could solubilise inorganic phosphates, while siderophores production was not recorded. Only few isolates had the ability to produce hydrolytic enzymes, while antifungal activity against tested fungi was not recorded. The most effective isolates were subjected to further molecular characterisation based on 16S rDNA sequence. Sequencing results showed that isolates DZM1Cm, DZK1Lm, PZR1Dm, DRZR2Cm, 631oz, 754 and 1M12 belong to *Mesorhizobium* genus (*Mesorhizobium* sp., *Mesorhizobium cantuariense*, *Mesorhizobium erdmanii*, *Mesorhizobium* sp., *Mesorhizobium* sp., *Mesorhizobium jervisi* and *Mesorhizobium* sp., respectively). The results of this research indicated that there is wide rhizobial diversity present in the root nodules of *Lotus corniculatus* L. Further research should be aimed towards exploring the potential application of identified effective root nodule rhizobia in contemporary agriculture and organic farming.

Keywords: *Lotus corniculatus* L., *Mesorhizobium* sp., nitrogen fixation, plant growth promotion, indole-3-acetic acid



Soils for Future under Global Challenges

MINERALOGICAL COMPOSITION OF GAJNJAČA SOIL IN KRNJEVO VITICULTURE AREA

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Abstract

Gajnjača or Eutric Cambisol occupies around 700,000 ha of the Republic of Serbia and presents soil type most suitable for fruit and vine production. Krnjevo viticulture area is characterized by vast area of Gajnjača soil which gives specific tone to grapes and wine itself. In order to reveal mineralogical composition of soil which influences wine character, we performed soil survey of Gajnjača and X-ray diffraction (XRD) of soil samples from soil horizons. Diffractograms were recorded on a Philips PW1710 diffractometer operating at 36 kV and 18 mA. Recording started at 4Θ , speeds 10/min; $R_c = 4/2$. XRD patterns of the bulk sample, oriented sample, sample saturated with ethylene glycole (EG) and sample heated at 550°C (clay fraction) were recorded. XRD analysis of Gajnjača humus–accumulative horizon revealed presence of quartz, feldspar and phyllosilicates (smectites, illite, chlorite). Similar mineralogical composition was determined in cambic (B)–horizon, but with a noticeable decrease in feldspar content. Lower feldspar content in the cambic horizon and the higher content of phyllosilicates compared to A–horizon, reflects a more intensive transformation of feldspars into phyllosilicates during the formation of the cambic horizon, where the largest mass of vine root is found.

Keywords: Gajnjača, viticulture, mineralogical composition, phyllosilicates



Soils for Future under Global Challenges

PEDOLOGICAL CHARACTERISTICS OF GREEK MAPLE (*ACER HELDREICHII* ORPH.) SITES IN SERBIA

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Abstract

Greek maple (*Acer heldreichii* Orph. subsp. *heldreichii*) is an endemic taxon of the Balkan Peninsula and a Tertiary relict. It is spread in the following countries: Serbia, Bosnia and Herzegovina, Montenegro, Northern Macedonia, Bulgaria, Greece and Albania. The species occurs only in mountain areas and in Serbia it has been recorded in the following mountain massifs: Rudnik, Goč, Željin, Jastrebac, Kopaonik, Golija, Javor, Javorje, Stara planina, Prokletije, Žljeb and Šar-planina. The northernmost site of this species is located in Serbia on the Rudnik Mountain. In addition to the typical subspecies, *Acer heldreichii* subsp. *heldreichii*, in the Caucasus grows a subspecies of *Acer heldreichii* Orph. subsp. *trautvetteri* and is autochthonous in the following countries: Turkey, Georgia, Armenia, Azerbaijan and Russia. Given that the greek maple, which is rare in Serbia and is a strictly protected species, is a subendemic of the Balkans and a Tertiary relict, the study of ecological conditions in which this species grows is of great practical importance in order to preserve its gene pool and ex situ conservation. Regarding this, pedological studies were performed on the most important sites of this species in Serbia. The studied edaphic characteristics at the investigated sites include determining the types of parent material and soil, as well as determination of physical and chemical soil properties. The results of the research are based on 14 soil profiles, four on Jastrebac and two soil profiles on each of the following mountains: Goč, Javorje, Stara planina, Rudnik, and Golija, respectively. Based on the determination of petrological material collected during the opening of soil profiles in the field, performed in the laboratory of the University of Belgrade Faculty of Forestry, it was determined that greek maple is found on eight different types of parent material at the studied sites. At the Rudnik site there are sandstones and clays, on Goč granites and granodiorites, on Jastrebac shales, phyllites and gneisses, on Stara planina sandstones, on Golija slates and phyllites, and on Javorje slates. Based on the pedological analysis, it was determined that there are two types of soil on the investigated localities, Cambisol (Dystric) and Leptosol. Leptosol was recorded only at the Jastrebac locality, on one soil profile. The analyzed soils are mostly medium deep to deep, with depths ranging from 35 to 73 cm, on average (49.77 cm). According to the classification of Tommerup (1934), the samples of the studied acid brown soil are: loamy, coarse to fine sandy loamy or clayey loamy mechanical composition. The humus content is relatively high and ranges from 3.0 to 26.25%, and decreases with profile depth. The reaction of the soil in water ranges from extremely acidic to very strongly acidic, with pH values ranging from 3.9 to 5.23. The content of total nitrogen is in accordance with the content of humus with values ranging from 0.14 to 1.3%. In terms of the content of easily available phosphorus and potassium, the studied soils in mountain maple communities are in the range of low to medium supply with phosphorus (1.2 - 18.0 mg per 100 g of soil), ie, from low to good with potassium (4.4 - 22.0 mg per 100 g of soil). Given that this species is a subendemic of the Balkan Peninsula and belongs to the strictly protected plant species in Serbia, this research will make a valuable contribution to the better understanding of the ecological conditions in which this species is found in Serbia.

Keywords: Greek maple, *Acer heldreichii* Orph. subsp. *heldreichii*, Serbia, Soil properties



COMPARATIVE ANALYSIS OF PHYSICO-CHEMICAL AND MICROBIOLOGICAL PARAMETERS OF SOIL UNDER *MISCANTHUS GIGANTEUS* GROWN IN DIFFERENT AGRO-ECOLOGICAL CONDITIONS

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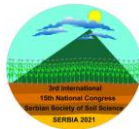
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Abstract

The aim of this research was to evaluate the impact of soil type (physico-chemical properties), dosage and the type of applied mineral fertilizer to the bioenergetic crop *Miscanthus x giganteus* planting in different agro-ecological conditions, on the microbiological parameters of the soil. Experimental plots with miscanthus were located at three sites in the territory of the Republic of Serbia. Institute's experimental plots under miscanthus were formed on different soil types: in Varna on the Stagnosol, in Mladenovac on the Cambisol and in Belgrade on Anthropogenic Soil. The analysis of agro-ecological conditions indicated that in Belgrade vegetation season started two weeks earlier, compared to the other two localities. Furthermore, higher values of the analyzed chemical parameters of the soil (pH value, content of easily accessible phosphorus and potassium, content of carbonate, organic matter and total nitrogen) were recorded for the Belgrade location, compared to the other two localities, while in terms of physical properties, each locality was of different soil texture class. Soil samples, in which this impact was analyzed, included treatments from experimental plots under miscanthus (fertilized with 50 kg ha⁻¹ NPK - granular fertilizer, with 100 kg ha⁻¹ NPK - granular fertilizer, 50 kg ha⁻¹ NPK - water soluble fertilizer and unfertilized variant) and uncultivated soil over a multi-year period. The total number of microorganisms was determined by the plate count method on the agarized soil extract. In the same manner, the number of microorganisms that could grow on a minimal medium enriched with miscanthus was determined. The results of this research indicated that the highest values for the total number of microorganisms were recorded for the soil from the Mladenovac location. Similar results were obtained for the Varna location, while the soil from Belgrade had the lowest number of microorganisms. The total number of microorganisms that could grow on a minimal medium enriched with miscanthus was the highest for the Belgrade location, while this number was slightly lower for the locations of Mladenovac and Varna. For the total number of microorganisms, differences in the number of microorganisms between treatments were also observed (in the range from 5x10⁵ to 3x10⁹ CFU/g). The highest number of microorganisms was observed in the treatments under miscanthus fertilized with 50 kg ha⁻¹ NPK - water soluble fertilizer, while the treatments from uncultivated soil showed the lowest number of microorganisms. A similar pattern between treatments was observed in the case of microorganisms grown on minimal medium with miscanthus. These results indicated that different soil types, fertilization treatments and agro-ecological conditions had an impact on the total number of microorganisms in the soils under the perennial bioenergetic crop of miscanthus. In addition, the cultivation of miscanthus in all localities increased the total number of microorganisms, in comparison to the uncultivated soil.

Keywords: *Miscanthus x giganteus*, microorganisms, soil type, agro-ecological conditions, fertilization



ORGANIC FARMING PRACTICE IMPROVES SOIL MICROBIAL PROPERTIES UNDER SOYBEAN PRODUCTION

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Abstract

To minimize negative impacts of intensive agricultural practice, organic farming has been proposed as a sustainable agricultural practice with the main principles of the ecological cycle and biodiversity. This concept heavily relies on an active soil microbial community to break down organic matter into plant available nutrients. The main objective of the study was to identify whether significant differences in microbial properties in soils under soybean organic and conventional farming management exist. The study included 95 samples of soil under certified organic soybean production and 48 samples in conventional production system. Soil samples were collected from soybean rhizosphere, in the period of soybean full bloom. The abundance of the examined microbial communities was assessed by an indirect dilution spread-plating method on an appropriate nutritive media. Dehydrogenase and β -glucosidase activity were measured spectrophotometrically. The variables were analyzed using two-way analysis of variance (ANOVA), followed by mean separation according to Tukey's test at the $P < 0.05$ level of probability. Soils under organic farming belong to the class of humic soils (3.5%), while soils samples in conventional fields were characterized by the lower humus content (2.1%). The results of the study showed significant increase in the abundance of *Azotobacter* spp., free N-fixing bacteria, actinomycetes and dehydrogenase and β -glucosidase activity in soils under organic management. The two different soil management systems did not significantly affect the total bacterial population, ammonifiers and fungal abundance. The abundance of *Azotobacter* spp., free N-fixing bacteria and actinomycetes were on average 196%, 87% and 60% higher, respectively, in organically farmed soils. Dehydrogenase activity was on average 140% greater, whereas the β -glucosidase activity was increased by 41% under organic management. As no synthetic nitrogen fertilizers are allowed in organic farming, these systems heavily depend on green manure, nitrogen fixation and organic inputs. Increased organic matter content in organic farming positively influences microbial growth, biomass and enzymatic activity. The present study underlying management practices linkage on most investigated microbial indicators and confirms the positive correlation with soil organic material turnover.

Keywords: dehydrogenase, β -glucosidase, microbial abundance, organic and conventional management, soybean



Soils for Future under Global Challenges

RESEARCH ON THE FAUNA OF EARTHWORMS (ANNELIDA: LIGOCHAETA) OF SOKOBANJA

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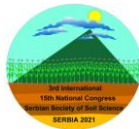
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Abstract

Soil is a complex and dynamic entity, made up of abiotic and biotic components. Earthworms are one of the most important organisms of terrestrial ecosystems. They are often presented as bioindicators of soil quality. That is why it is extremely important to know their diversity, ecology and distribution. The aim of this paper is to present new data on the earthworm fauna of Sokobanja and to summarize the published data. The list underlines earthworm diversity and provides a general overview of their distributions, zoogeographical positions, and ecological categories. The earthworms were obtained by the diluted formaldehyde method complemented with digging and hand sorting as well as turning over rocks, debris, and logs. The total number of earthworm species in Sokobanja comprises 7 taxa belonging to 7 genera. Our analysis showed that almost all species are peregrines (six out of seven). The only species of *Dendrobaena byblica byblica* is Circum-Mediterranean. According to the ecological category classification, four species were epigeic, two species were endogeic, and one species was anecic. In our research, we found three new species for this area (*Aporrectodea rosea*, *Dendrobaena byblica byblica*, *Eisenia fetida*). The Lumbricidae fauna of Sokobanja, with several cosmopolitan species, is fairly uniform. However, the investigations are still insufficient and the earthworm inventory of Sokobanja is far from complete. Also, in order to protect the biodiversity, we need to increase our knowledge of biological diversity, especially considering its link to the soil functioning. Hence, this study indicates the importance of such studies.

Keywords: earthworms, soil, Sokobanja, Serbia



Soils for Future under Global Challenges

SOIL STRUCTURE OF CALCOMELANOSOLS FROM THE RTANJ MOUNTAIN, SERBIA

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Abstract

Soil structure pertains to the natural organization of soil particles into various forms as a result of pedogenic processes. On one hand, it is formed in interaction of physical, chemical, mineralogical, and biological factors, whereas on the other hand it affects them. Soil structure can differ in grade of development, size and type of aggregates, and their stability to mechanical pressure and water, which is often soil-horizon or soil-type dependent. This paper aims to analyze the structure of Calcomelanosols of Mountain Rtanj, Serbia, as that is the most widespread soil type in this area. Calcomelanosols are soils from the national classification system that often correspond to Rendzic Leptosols in the World Reference Base (WRB) for soil resources. Soil structure is analyzed in terms of soil dry aggregate size distribution (ASD) and soil aggregate stability to water (WAS), and related soil structure indices, as they are essential parameters in understanding the structural state of the soil. Eight soil profiles have been excavated, described and sampled in the field. Soil horizon sequence of all profiles was A – R, with humus-accumulative horizon overlying calcareous bedrock. Six profiles of Calcomelanosols correspond to Rendzic Leptosols of WRB, whereas other two profiles correspond to Leptic Rendzic Phaeozems and Leptic Chernic Rendzic Phaeozems. Basic physical and chemical soil properties were determined. Both ASD and WAS were determined by Savinov's method. The following soil structure indices were calculated: dry mean weight diameter (dMWD), wet mean weight diameter (wMWD), dry geometric mean diameter (dGMD), wet geometric mean diameter (wGMD) and structural stability index (SI). The results indicate favorable structure of the examined Calcomelanosols. The content of agronomically most valuable aggregates (0.25–10 mm) in all soil profiles exceeds 80% (90.47±3.57% on average). Among these aggregates, very fine, fine and medium size aggregates dominate. Dry MWD showed values ranging from 3.02–5.53 mm, whereas wMWD ranges from 1.92–3.34 mm. The wMWD and dMWD ratio is an indicator of the stability of structural aggregates. A small change in the aggregate size after wet sieving was found, 0.67±0.11 mm on average. In all examined soil profiles SI is higher than 19% (32.91±7.05% on average), which indicates an extremely stable structure, without risk of the structural degradation of soil. Correlation analysis showed a significant positive relationship between the content of agronomically valuable fractions (0.25–10 mm) and the following soil parameters: soil organic matter (SOM), pH, and base saturation (%V). Also, there is a strong positive correlation between SI and pH, and SI with %V. Other calculated structural indices show a strong negative correlation with SOM, pH and %V. All analyzed soil profiles have favorable soil structure and water stable soil aggregates with low risk of soil structure degradation. This is of extreme importance because Calcomelanosols cover the steep and sloping land which is naturally more prone to soil water erosion and soil degradation.

Keywords: MWD, GMD, structural stability index, Rendzic Leptosols, Leptic Rendzic Phaeozems, Leptic Chernic Rendzic Phaeozems



SOIL CLASSIFICATION AND PHYSICAL PROPERTIES OF SOILS OF ŠUMADIJA REGION UNDER PLUM ORCHARDS

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Abstract

The Republic of Serbia is one of the biggest producers of plum fruit, and takes a high third global position. Also, one of the most popular Serbian breeds is plum brandy (Šljivovica). The aim of the detailed soil research in the Šumadija region is the protection of the products with the geographic origin. The soil was examined on 18 different locations. A total number of 176 disturbed soil samples, and 96 undisturbed soil samples were collected. The research was conducted in the summer and in the autumn of 2019.

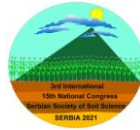
Šumadija region is rich in pedodiversity and different soil types are distributed over the region: Vertisols, Eutric Cambisols, Luvisols, Regosols, Dystric Cambisols, Fluvisols, Pseudogleys, Terra rosas, and Litosols. Classification of the examined soils under plum orchards was determined on the basis of 8 soil profiles, and 13 hand augerings, which were located on representative sites. More than a half of observations (11 of 20) are classified as Vertisols. Eutric Cambisols were identified on five, and Luvisol on four sites. According to the World Reference Base for Soil Resources (WRB) the above identified soils belong to following Reference Soil Groups: Haplic Vertisols, Eutric Cambisols, and Vertic Luvisols.

Knowledge about the soil physical properties is of the great importance compared to the other soil properties due to their direct and indirect influence on the general soil conditions, water, air and thermal regime of the soil, and furthermore, soil chemical and biological properties. Bulk density in the most analysed samples within the study area increases with the depth as a consequence of the pressure of the top layers. In some cases exists some exceptions where the top layer has higher values, due to the influence of the agricultural mechanization. The values of bulk density range from the class of semicompacted plowed land to the class of very compacted illuvial horizons. At the most of the examined sites, the total porosity is higher in the surface soil horizons, whereas on several sites the values are very similar in both examined horizons. According to the filtration rate (soil permeability), most of the examined soils are moderately permeable and poorly permeable. Soil subsurface horizons are less water-permeable.

Most of the analyzed samples belong to loamy clay texture class. Significant differences in particle size distribution were found between the surface and subsurface soil horizons. As the depth increases, the clay content also increases, which makes the soil more difficult for the growth and development of the root system of the plums, as well as for cultivation.

Keywords: geographic origin, plum production, soil classification, soil physics.

This study was conducted as part of the Project “Soil fertility control and content of dangerous and hazardous substances in soil of plum orchards in Šumadija region” (2019), which is supported by the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia.



THE VALUE OF DIFFERENT TYPES OF ACIDITY OF PSEUDOGLEY SOILS IN THE KRALJEVO BASIN UNDER DIFFERENT LAND USES

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Abstract

This paper presents the results of active (pH in H₂O), exchangeable (pH in KCl), hydrolytic (Y1) and total acidity (T–S) in humus–accumulative (Ah, Ahp) and subsurface (Eg, Btg) horizons of Pseudogley Soils in Kraljevo Basin for 14 soil profiles excavated in forests, 16 in meadows and 24 on arable land. The results showed that acidification was weaker or more pronounced in all three most important tested horizons of Pseudogley Soils, and that the differences in the value of different forms of acidity existed among forest, meadow and arable soils, as well as among horizons of the same profile. The chemical reaction of soil solution ranged from very weak to extremely acid. The highest active acidity was found in forest profiles, especially the ones in deeper horizons. Exchangeable acidity ranged from 3.7 to 4.9 pH units, with the forest profiles as the most acid, while the differences between meadow and arable land were less pronounced. The highest hydrolytic acidity was measured in the forest profiles, while acidity in meadow and arable land profiles was significantly lower and the lowest, respectively. Total acidity of the Kraljevo Pseudogleys ranged from 6.2 to 24.8 meq/100 g soil and similarly to hydrolytic acidity, the value of total acidity was affected by land use.

Keywords: different types of acidity, Pseudogley Soil, forest, meadow, arable land



Soils for Future under Global Challenges

SECTION 2: SOIL-WATER-PLANT-ATMOSPHERE CONTINUUM



Soils for Future under Global Challenges

PROPERTIES AND GROUNDWATER LEVEL OF HUMOGLEY SOIL OF SOUTHERN BAČKA

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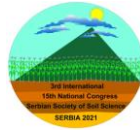
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Abstract

The paper examines hydromorphic soils from the class of gley soils, soil type Humogley. The examined soils are located in the protected part of the inundation of the middle course of the Danube. According to the chemical properties of the examined soils, the pH value ranges from 7.64 to 8.15 on average, and with depth there is an increase in alkalinity. The total salts of the examined soils had increased values in the humus horizon and ranged from 0.06 to 0.09%. The texture classes of the humus horizon of these soils are: clay loam to sandy clay loam, while the lower sub-horizons of the gley are textural classes of sandy loam, loamy sand and sand. The influence of the Danube water level on the groundwater level results in high correlation coefficients, which range from 0.67 to 0.87. The groundwater in these soils had the highest level from 28 cm to 72 cm depth, and the lowest level was from 110 to 175 cm deep. The amplitude of groundwater variation during the year in the examined Humogley soils ranges from 66 to 132 cm. Groundwater quality classes according to U.S. Salinity Laboratories are unfavorable and range from C3S1 to C4S1, ie salt to very salty water with low sodium content, and according to the FAO classification the water quality is such that there is a moderate need for restriction. High groundwater level above the critical level, as well as watering the soil with water of this quality can have an impact on salinization of the surface horizon of Humogley soil of the examined area.

Keywords: Humogley, groundwater level, groundwater quality



Soils for Future under Global Challenges

EFFECT OF *CHLORELLA VULGARIS* ON SWISS CHARD (*BETA VULGARIS L. VAR. CICLA*) GROWTH PARAMETERS AND YIELD

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Abstract

Swiss chard (*Beta vulgaris L. var. cicla*) is a leafy vegetable which is grown in Serbia mainly in home gardens on smaller areas. It is highly valued for its nutrient composition, resistance to low temperatures, pests and for its high yield. Microalgal application in plant production could improve quantity and quality properties of the crop but also its aroma and flavor. In this research, foliar application of three *Chlorella vulgaris* strains on Swiss chard growth parameters (average leaf number, leaf length, weight per leaf, total weight per plant and average yield per treatment) were investigated. The highest yield (60.91 t ha⁻¹) was achieved by application *C.vulgaris* strain 63. This strain proved to be the most effective for the majority of morphological parameters such as average leaf number, weight per leaf and total weight per plant (15.7, 29.9 g leaf⁻¹ and 454.6 g plant⁻¹, respectively). *C. vulgaris* strains 71 also proved as a potentially good plant growth promoter. According to the obtained results, *C. vulgaris* based fertilizers could substitute conventional fertilizer in terms of achieving high Swiss chard yield.

Keywords: leafy vegetables, Swiss chard, *Chlorella sp.*, yield.



Soils for Future under Global Challenges

GROSS SOIL SURFACE BALANCES OF N, P AND K UNDER ORGANIC AND MINERAL FERTILIZATION

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Abstract

The intensification of agriculture over the last few decades has strongly increased global food production, but with a high environmental impact. Facing these issues the European Union as well as governments of individual countries introduced the regulations limiting emissions to soil, air and water, which require policy instruments like nutrient budgets. Nutrient balances provide insight into links between agricultural nutrient use and losses to the environment, as well as sustainable use of soil resources.

Field experiments were carried out to assess the effect of mineral and organic fertilization on the balances of nitrogen, phosphorus and potassium.

It was found that the increase in nitrogen doses elevated the uptake of nitrogen and phosphorus by maize, leading to a decrease in N and P gross balances. Fertilization slightly differentiated the potassium balance. Overall, the results of the study strongly indicate the importance of sustainable, closed-cycle nutrient management in agroecosystems. Further investigation is still needed to reveal the complexity of the factors affecting nutrients uptake and bioavailability under differentiated fertilization.

Keywords: Fertilization, Nutrient management, Soil nutrient balance, Nutrient use efficiency



Soils for Future under Global Challenges

IMPACT OF BARK BEETLE-INDUCED FOREST DIEBACK ON SOIL BASE CATIONS AND NITRATES, AND ITS CONSEQUENCE ON FRESHWATER COMPOSITION

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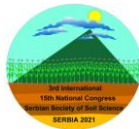
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Abstract

Norway spruce forests across the whole Czech Republic have been currently severely disturbed by bark beetle outbreaks. Such disturbances have impact not only on vegetation, but also on soils and freshwater. Thus, the impact of bark beetle-induced tree dieback on the chemical properties of uppermost organic soil horizons was studied in an unmanaged forest mountain catchment in Šumava national park (Czech Republic). Bark beetle outbreak lead to an extensive dieback of Norway spruce forest there, formerly weakened by long-term anthropogenic acidification due to long-distance atmospheric transport of S and N compounds. As this area falls into a national park's non-intervention zone, all dead biomass remained on the forest floor. Data from affected catchment (Plešné Lake) were compared to unaffected control catchment of Čertovo Lake. Both affected and control catchments are of the same elevation (~1100–1350 m a.s.l.), have similar vegetation (forest dominated by Norway spruce) and similar relatively thin soil cover, formed mainly by Leptosol, Podzol, and Spodo-Dystric Cambisol. Soil chemistry was checked in regular six-week intervals since 2008 to 2020 on the sampling sites placed in lower part of catchments. Moreover, soils were sampled throughout the whole catchments in 2000, 2010 and 2020. Chemical composition of streams draining the catchments was checked in 3-week interval. The content of exchangeable cations and the concentration of nitrate represented soil chemical parameters which were affected quickly after the forest dieback. The average pool of exchangeable base cations doubled (from 1050 to 2200–2400 mmol m⁻²) in the upper ~20 cm of soil during 2008–2020, because their release from dead biomass exceeded losses via leaching and tree uptake. The surplus of non-acidic cations replaced ~50% of the exchangeable acidity (Al³⁺ and H⁺), which was leached out from the soil sorption complex to receiving waters. Pool of nitrate increased 20 times during three years following forest dieback (from 1.6 to 33 mmol m⁻²), and then was gradually decreasing to original values till 2020. Changes in the soil sorption complex were well mirrored also in the chemistry of streams draining the affected catchment. Increased concentrations of base cations in water were in concert with their elevated content in soils (leaching of surplus base cations), while ionic Al concentrations in streams increased as a result of their displacement from soil sorption complex. The transport of cations from the catchment balanced the increased terrestrial export of nitrates, with further consequences for lake water chemistry. Described changes in soil chemistry in an unmanaged forest represent natural conditions, thus the uppermost limit of an ecosystem response to possible management practices based on biomass removal in similar mountain forest areas.

Keywords: Bark beetle outbreak, Forest floor, Soil exchangeable cations, Soil Nitrate, Leaching from soil to freshwater



Soils for Future under Global Challenges

ASSESSMENT OF A SMARTPHONE APP FOR POTATO IRRIGATION SCHEDULING

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Abstract

Information and communication technologies (ICT) are the base to develop tools to help farmers with irrigation scheduling. In Lebanon, in order to provide a step towards improved agricultural water use, technological advances and fundamental irrigation principles should be more investigated particularly through testing mobile app that are currently being developed worldwide. Therefore, an irrigation scheduling tool, called Bluleaf, currently developed and tested by an Italian consortium of private ICT companies and Research institutions was tested in the Bekaa valley. Bluleaf is a multiplatform application consisting of a PC and a mobile module. It takes into account agro-climatic, soil data and information related to the hydraulic system and offers farmers information about the required irrigation intervals and amounts. The main objective was to assess the performance of Bluleaf smart irrigation scheduling application for potato production in the Bekaa valley during the growing season 2017. Therefore, a field trial was implemented, it was organized in 16 plots within a randomized complete block design consisting of four irrigation scheduling treatments and four block replicates: I - 100: 100% replenishment of soil water depleted when 35% of available soil moisture was consumed in the 0.6 m soil profile depth; I - 80: 80% replenishment of soil water depleted; I - 60: 60% replenishment of soil water depleted; I - 40: 40% replenishment of soil water depleted. Bluleaf was used to track when and how much water to supply. The soil moisture content was tracked. In addition, the yield and water productivity were estimated. The validation of the soil water balance in Bluleaf was assessed through the analysis of some statistical indicators such as the Nash-Sutcliffe coefficient (NSE), that were applied to evaluate model predicted and observed data of soil water content. The midday leaf water potential was measured in addition to the canopy infrared temperature for the estimation of the crop water stress index. Obtained results revealed that Bluleaf simulated the soil water dynamics with a good agreement with measured values considering the amount of spatial variability and soil heterogeneity. In fact, the goodness of fit indicators, such as the NSE showed that the model was classified as good, with values ranging from 0.80 to 0.88. The obtained results showed that Bluleaf could constitute a good tool for simulating not only irrigation schedules under optimal water stress but also under limited water conditions. Bluleaf was able to support real-time scheduling with respect to the specific crop response to stress and with respect to the need to save water.

Keywords: Irrigation scheduling, wheat, potato, smartphone application



Soils for Future under Global Challenges

DECOMPOSITION OF SILVER BIRCH LEAF LITTERFALL AND NUTRIENTS RELEASE AT POST-ARABLE STANDS UNDER TEMPERATE CLIMATE

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Abstract

The studies on leaf litterfall decomposition in silver birch stands were performed in Central Poland (temperate climate; mean annual temperature ~ 8.3°C; average annual sum of precipitation ~ 538 mm). Five stands on Brunic Arenosols representing nutrient-poor soils and five stands on Cambisols as nutrients-rich soils have been studied. Moreover, the stands varied in terms of age (15 - 80 years) and forest habitat type (8 stands on post-arable soils and 2 stands on forest soils). Litterbag method was applied in this study. 15 g of initial material was placed into litterbags (1 mm mesh) and exposed. Decaying materials were sampled every 3 months at 3 replications, dried at 65°C, weighted, milled into powder and analyzed. Contents of C, N and S were determined by dry combustion (Vario MacroCube, Elementar), P, K, Ca, Mg, Fe, Al, Mn, Cu and Zn by the ICP-OES (Avio 200, Perkin Elmer) after samples digestion in nitric acid using the microwave digestion system (Milesotene) and pH potentiometrically in a suspension with water. Initial materials used in this experiment were acidic, rather poor in major nutrients (6225.5 – 12371.0 mg kg⁻¹ of N; 1026.6 – 2734.3 mg kg⁻¹ of P and 3252.1 – 8206.8 mg kg⁻¹ of K). C:N ratio varied from 39.3 to 76.1, indicating potentially slow rate of decomposition. Initial materials collected from the stands growing on Brunic Arenosols were in general more abundant in N, P and S. The remaining elements did not show clear differences. During the 15 months of experiment decomposed 38.0 – 75.1% of initial mass of birch leaves. Decomposition rates (*k*) varied from 0.38 to 1.12. Generally, higher intensity of that process was observed in older stands as compared to younger. Soil type was less important factor influencing decomposition, that is quite surprising. Differences observed between the oldest stands covering post-arable and forest sites were not significant statistically. Release patterns of the studied macro- and micronutrients showed typical trends in most cases. Contents of N, S, Fe, Al, Cu and Zn gradually increased, however reasons of that trend varied among elements. P contents decreased at Brunic Arenosol stands and were relatively stable on Cambisols, whereas K was rapidly released at every stands. The contents of Ca, Mg, Mn remained relatively stable, however strongly varied among the stands in some cases.

Keywords: Silver birch, Post-arable soils, Afforestation, Litterfall, Soil organic matter

The studies were supported by the National Science Centre, Poland, project no. 2018/31/B/NZ9/01994 entitled „Transformation of post-arable soils due to afforestation with birch“



EFFECT OF DRIP IRRIGATION ON YIELD, EVAPOTRANSPIRATION AND WATER PRODUCTIVITY OF POTATO IN SEMIARID ENVIRONMENT

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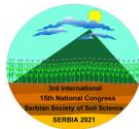
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Abstract

Field experiment was conducted to study the effects of drip irrigation on potato (*Solanum tuberosum* L.) tuber yield, evapotranspiration and water productivity. A trial with irrigated potato was conducted on a private farm in Čenej (45°22' N latitude, 19°47' E longitude and 85 m.a.s.l.) near Novi Sad, in the Calcic Chernozem soil, in 2020. The trial was established as a block design adapted to the technical specifications of the drip irrigation system. Non-irrigated, control variant was included as well. Irrigation was scheduled on the basis of water balance method. Daily water used on plants' evapotranspiration was calculated by multiplying reference evapotranspiration with crop coefficients. Crop coefficients were 0.5, 0.7, 1.1, 0.9, 0.7 from planting to emergence, early vegetative development, tuber initiation, tuber enlargement and senescence respectively. Daily reference evapotranspiration values, calculated by the Hargreaves equation, were taken from the website of the Republic Hydrometeorological Service of Serbia. Irrigation started when readily available water in the soil layer of 0.4 m was completely absorbed by plants. The irrigation rate was 30 mm at the beginning of the season and 40 mm in the middle of the season. Calculation of water productivity, irrigation water use efficiency and evapotranspiration water use efficiency were based on yield and evapotranspiration of potato in conditions with and without irrigation and irrigation water applied. Results indicate a significant effect of irrigation on potato yield (58.06 t ha⁻¹) in regard to the non-irrigated variant (38.33 t ha⁻¹). In the study period, seasonal evapotranspiration in irrigation conditions and the rainfed control variant were 478 mm and 319 mm respectively. Irrigation water use efficiency and evapotranspiration water use efficiency values were 9.39 kg m⁻³ and 12.40 kg m⁻³ respectively.

Keywords: potato, drip irrigation, yield, evapotranspiration, water productivity



Soils for Future under Global Challenges

FUNGAL MICROBIOME OF FOREST SOIL: A HIDDEN MICROCOSMOS UNDER BLUEBERRY ROOTS

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Abstract

Soil fungi are crucial component of ecosystem biodiversity, stability and health. They play an irreplaceable role in energy streaming, nutrient cycling, organic matter mineralization and degradation, and the establishment of symbiotic and pathogenic interactions with plants. Together with bacteria residing in soil, they build a micro basis for plant growth, development, functioning, and productivity of the whole ecosystem. Natural forest ecosystems provide a unique perspective for the study of the soil microbiota. Those ecosystems are less exposed to anthropogenic impact compared to planted forests or agricultural soils. A great microbial diversity observed in them is a key to improve soil health and biogeochemical cycles. Realizing the importance of this, the aim of this study was to examine fungal diversity of natural forest soil. Soil samples used for microbiome analyses were taken from area settled in Nature Park Golija (Ivanjica, Serbia) covered with mixed beech-fir-spruce forests (*Piceo-Fago-abietetum*) and blueberry shrubs (*Vaccinium myrtillus* L.). Soil samples were mixed with DNA/RNA Shield (Zymo Research, Irvine, CA), which is a preservative of the genetic integrity of the sample. Soil samples are subjected to analysis by the ZymoBIOMICS® Targeted Sequencing Service for Microbiome Analysis (Zymo Research, Irvine, CA). The results showed that *Ascomycota* are the most present (53.80%), followed with *Basidiomycota* (27.60%), and *Mucoromycota* (6.50%). The share of unidentified members of fungal community is 10.30%. Within the *Ascomycota* group *Leotiomyces* are dominant (29.90%). This class is consisted of ecologically diverse representatives who form mycorrhiza, colonize inner tissues of roots and leaves, and act as a plant and mammals pathogens. Among *Leotiomyces* 12.80% are *Helotiales*. Order *Helotiales* is related to *Vaccinium* sp. and mainly consisted of fungi which form ericoid mycorrhiza, crucial for *Ericoidaceae* accommodation to low pH value and low organic matter transformation. Within the *Basidiomycota* group *Agaricomycetes* are dominant (24.80%) with *Agaricales* and fam. *Clavariaceae* as the most present. *Mucoromycota* share is 6.50% and those fungi are very important in ecosystem functioning since the majority is involved in mineralization of very complex organic matter (pectin, hemicellulose, lipids, proteins). Those fungi are pioneers in ecological succession processes of different substrates. *Mucoromycota* establish a wide range of interactions, from useful to pathogenic, with their green hosts. Among them class *Mortierellomycetes* are mainly present in rhizosphere while *Glomeromycetes* are well-known as the widespread arbuscular mycorrhizal fungi. Obtained results show that better microbiome understanding may open new possibilities and rise usage of useful plant-microbe interactions in forestry and agriculture.

Keywords: natural forests, blueberry, soil microbiome, *Ascomycota*, *Basidiomycota*, *Mucoromycota*



Soils for Future under Global Challenges

THE INFLUENCE OF BIRCH AFFORESTATION OF POST-ARABLE SOILS ON SOIL ORGANIC MATTER COMPOSITION

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Abstract

The effects of afforestation with birch of post-arable soils on soil organic matter (SOM) composition in humus horizons was studied in central Poland. Post-agricultural soils of different fertility under stands with birch trees of various ages (10-20, 25-35, 40-50 and 55-65 years) were examined. Additionally the studies covered 55-65-year old stands at natural forest habitat. Finally, 10 stands were selected for the research: five stands located in complexes of Brunic Arenosols, representing light-textured, poor in nutrients soils (4 of post agricultural soils, 1 in natural habitat) and five in Cambisols, as medium-textured, more abundant in nutrients soils, in the same combination. Each stands included 2 plots - one in a forest habitat, the other in nearby field of the same textural class. SOM fractional composition was analyzed using the procedure described by Chen et al. (1978).

A different effect of birch was found in Arenosols and Cambisols. In light post-agricultural soils less carbon of humus acids and the fraction strongly associated with the mineral part of the soil under the birch compared to a farmland was observed. This influenced the difference in the total amount of TOC. Birch also affected the reduction of HA/FA ratio. In medium-textured soils the amounts of TOC were similar in forest and arable soils.

In the stands of the young age classes (up to 33 years), the amounts of HA and FA were higher in soils under the birch than in the cultivated field. With the age of the stands (older than 40 years) the situation changed and the cultivated soils were characterized by a greater amount of humus acids and a greater degree of humification than post-agricultural soils.

The research has shown that afforestation of agricultural land with birch deteriorates the properties of humus, especially on light soils.

Keywords: birch, afforestation, post arable soils, soil organic matter

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Soils for Future under Global Challenges

IMPACT OF NATURE BASED SOLUTIONS FOR FLOOD RISK MANAGEMENT ON SOIL AND AGRICULTURAL DEVELOPMENT - EU CONSIDERATION AND SERBIAN PROSPECTIVE

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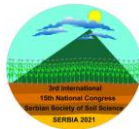
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Abstract

Throughout history, floods have played one of the major roles in soil formation, and in maintenance and alterations of soil fertility. The overflowing of rivers left silt full of organic matter in the fields, salts were washed out of the soil, and a large amount of water was retained in the soil profile. The construction of cities on the banks of rivers, the regulation of water flow, and the construction of embankments for flood protection, narrowed riverbeds and increased hydraulic flow, resulted in a more intense concentration of flood waves during high waters and in shortening of flood management time. Since the beginning of the 21st century, numerous large-scale floods have occurred throughout Europe. Various climate models indicated an increase in the frequency and intensity of future flood events. The embankments were built to hold flood waves of a return period of 50 years on smaller watercourses and 100 years on large rivers. Floods with higher return periods may or may not occur at all. In this regard, embankments are no guarantee that cities and agricultural land can be successfully protected from floods, so their upgrading is questionable. In recent decades, there has been an extensive debate about the use of agricultural land for flood protection of cities and industrial zones, on the cost of land and agriculture. Since private property is involved in both cases, a compromise solution should be found that satisfies all stakeholders. The main theme of the COST project LAND4FLOOD is to consider all aspects of flood risk management and land management such as: geographical, hydrological and hydraulics, ecological (soil pollution, compaction, water retention, ecological services, reconstruction of habitats), agricultural (agricultural development in the area reserved for temporary water retention), economic (how to compensate damages or incentivize flood retention service, public subsidies), public participation (how to ensure the participation of landowners), property rights issues (how to allow temporary flood storage and what this entails for agricultural land use), and sociological. The aim of this paper is to present some reflections on flood risk management and its implications for land and agricultural development in the EU and surrounding countries, as well as examples of good practices.

Keywords: Soil, Flood, Nature-based solutions, agriculture, LAND4FLOOD



SYNERGISTIC EFFECT OF *BACILLUS* ISOLATES AND BIOMASS ASH ON SOIL AND BARLEY PLANT QUALITY

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Abstract

The production of heat and electricity through the thermal use of biomass has increased in the last fifteen years. In parallel with this way of energy production, there was a strong increase in the amount of combustion residues. The utilization of biomass ash in agriculture may have two advantages. It could contribute to the sustainable management of soil fertility and solve the problem of ash deposits. In combination with microbial inoculants, they can have a beneficial effect on plant growth. The research studied the influence of biomass ash and *Bacillus* inoculums on the quality of soil and barley plant. Biomass ash was collected after the combustion of soybean straw, while *Bacillus* sp. were isolated from the rhizosphere soil of alfalfa. The presence of PGP traits (Indole-3-Acetic Acid and siderophores) was confirmed by quantitative tests for the three *Bacillus* isolates used (B1, BS1, BMG1). Inoculation of seeds with *Bacillus* inoculums (*in vitro*) showed a significant effect on seedling growth compared to the uninoculated control. The greenhouse pot experiment included five treatments and two controls. Treatments included soil (3 kg/pot) and biomass ash (30 g/pot) with and without calcium ammonium nitrate (CAN, with 27% of nitrogen, 0.3 g/pot) or with bacterial inoculum (1 mL of overnight B1, BS1 or BMG1 culture), while controls included experimental soil with and without the addition of CAN. The ash, soil and plants (collected in crop maturity stage) samples were tested for: total N, C, S, and plant available P₂O₅ and K₂O and the content of potentially toxic and hazardous microelements (As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn). Biomass ash addition significantly reduced soil acidity and increased the content of available P and K compared to controls. In the treatments where ash and microorganism were added in combination, the content of available P increased compared to the ash treatment. The yield of barley biomass increased more than twice in ash treatment and 87.62 % in ash+BMG1 treatment compared to the control (without any additives). The lowest barely yield was obtained in control where CAN fertilizer was added. Content of potentially toxic microelements in soil and barley shoots were below the maximum allowed concentrations. Application of biomass ash alone was effective in terms of soil nutritional and physical properties resulting in yield increase. The addition of ash in combination with *Bacillus* isolates resulted in a higher barley biomass yield than the combination of ash with CAN. This study showed that the analyzed biomass ash could be used as a fertilizer on acid soils with low nutrients content alone or in combination with bacterial inoculants. This synergistic effect can give an eco-friendly approach in agriculture in order to reduce the need for chemical fertilizers.

Keywords: *Bacillus*, biomass ash, soil, plant, nutrient, trace elements.



MICROBIOLOGICAL-SANITARY QUALITY OF SOIL AND SAFE VEGETABLE PRODUCTION

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Abstract

The soil represents dynamic, alive resource and it is very important for food production and the functioning of ecosystems. The soil microorganisms provide its fertility and productivity but the soil also could be a reservoir of human pathogens. The most important sources of pathogens in the agroecosystem are inadequately treated manure, waste sludge, contaminated irrigation water. Vegetables, grown in contaminated soil, are a good environment for human pathogens.

The Republic of Serbia is the largest regional producer of vegetables but with increasing fresh vegetable consumption there are possibilities for contamination by soil human pathogens that can cause serious diseases. Health risks from pathogens in soil, water and food are highly dependent on their transport and survival in agroecosystems. It is known that human pathogens are able to colonize plant tissues and could be transported to edible parts of plants, so the sanitary quality of the soil is extremely important for the safe production of vegetables.

Considering that such research has not been carried out to the narrow area of the Republic of Serbia so far, the aim of this study was investigation of microbiological and sanitary quality of soils and vegetable which are produced on those soils.

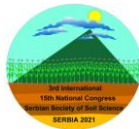
The sampling of soils and vegetables was done from fields and green-houses at 6 locations of the municipality of Leskovac. The vegetable samples were: tomato, pepper and cabbage. Microbiological analyzes of soils and vegetables included the detection of total bacteria count; total and fecal coliforms; enterococci; *Pseudomonas aeruginosa*.; *Salmonella* sp.; *Escherichia coli*; *Listeria monocytogenes*; Microbiological analyzes of vegetables were done according to standard methods prescribed by the Rulebook of food hygiene of production of the Republic of Serbia.

The results of the analysis showed that 7 out of 13 vegetable samples were positive on *Salmonella* sp., which was isolated from pepper (5 samples) growing in green-house condition. *Salmonella* sp. was also found on pepper and cabbage (1 sample each) growing in the field.

The presence of *Escherichia coli* and enterococci was detected at all investigated vegetable samples, but the highest number was noticed at pepper. *Pseudomonas aeruginosa* was only detected at cabbage. The *Listeria monocytogenes* was not found out in any vegetable sample. The number of coliform bacteria in the soil ranged from 302.7 (average in greenhouses) to 372 (average in fields) MPN/gDM.

This study points out to necessity for new agricultural models which would enable high productivity with less risk for human health.

Keywords: human pathogens, vegetable, soil, coliforms, *Escherichia coli*, *Salmonella* sp.



WATER QUALITY MONITORING OF THE FIRST AQUIFER IN THE AREA OF IRRIGATION SYSTEMS OF SOUTHWESTERN BAČKA

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Abstract

The groundwater of the first aquifer in Vojvodina is more or less mineralized, which is closely related to the hydrology, geology, and geomorphology of the Pannonian Plain. Irrigation increases soil productivity and the effectiveness of applied agronomic measures. However, irrigation can cause soil degradation and reduced yields in case the soil and irrigation water quality is not compatible. In addition, in conditions of intensive irrigation, the level and quality of groundwater may be impaired. To determine the water quality of the first aquifer on four irrigation systems in the area of southwestern Bačka, six piezometers were installed to observe, monitor, and collect data on the state and regime of groundwater over a long-term period (four piezometers were installed on chernozem soil and two on meadow soil). The paper presents the results of groundwater quality testing before the commissioning of the irrigation system as well as during the operation of the system on two occasions for monitoring purposes. The American Salinity Laboratory classification and the FAO classification were used to assess water quality.

The values of the total concentration of ionized components and the ionic balance indicate that the quality of groundwater from all piezometers and in all three examined terms was mainly in the C3S1 class according to the US Salinity Laboratory classification. It is salt water with a low content of sodium, in which dominate the water-soluble salts consisted of bicarbonates of calcium and magnesium, which in poorly drained soils can cause the process of salinization but not alkalization. The determined chemical composition of groundwater can pose a danger in terms of salinization of the soil in the zone of the root system, in the case when the groundwater level is above the critical depth for a long period. Salts from groundwater can accumulate near the surface of the soil, through the capillary rise, especially in the absence of abundant rainfall. For these reasons, it is necessary to periodically control the salinity and salt balance of the soil, to prevent the harmful process of salinization and alkalization of the soil in the future.

Keywords: water quality, groundwater, monitoring, salinization



Soils for Future under Global Challenges

THE EFFECT OF GRASS COVER N FERTILIZATION ON QUALITY OF CABERNET SAUVIGNON CV GRAPES

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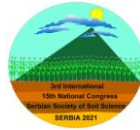
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Abstract

The experiment was set up in vineyard of "Radovanović" winery, with sown grass cover in inter row spaces. Row spacing is 2.4 m and 0.9 m between vines in row. Guyot training system was used and clones examined were Cabernet sauvignon VCR: 169, 191, 412 and ENTAV 15. Two layers of soil (surface 0-30 cm depth and subsurface 30-60 cm depth) were examined on soil fertility parameters: pH value, total N, organic C, quantity of available K₂O and P₂O₅. The inter-row space was sown with a grass-legume mixture composed of 60% red fescue, 30% perennial ryegrass and 10% white clover. The experiment with the grass-legume mixture was set up in 2020 and the mixture was fertilized by nitrogen fertilizer (ammonium nitrate) during the budbreak growth stage with doses of 0, 50 and 100 kg ha⁻¹. The random block design system was applied in three repetitions, with plots in a row spacing of 10 m². The dry biomass yield, nitrogen content in biomass, and visual assessment of lawn quality under the influence of nitrogen application were monitored. The aim of the research was to determine the influence of grass cover and N fertilization on grape quality in the vineyard inter rows maintained according to the criteria of optimal lawn management. Grape quality is shown through content of sugar and total acids expressed as tartaric acid content in grape juice-must, pH and glycoacidometric index. The grass cover temperature was measured with a thermal imaging camera (FLIR, T335) twice during the vegetation period. The obtained images were analyzed on a sample of 30 temperature spots per treatment. The average grass cover temperature for all treatments during the first measurement date varied from 22.0 °C to 30.7 °C, averaging 25.9 °C. During the second measurement, it varied from 27.9 °C to 33.8 °C, averaging 30.4 °C. The effect of the clone was significant on the grass cover temperature, while the effect of fertilization treatments was not significant. In both measurements, the highest temperatures were obtained for clones 169 and 15 which were similar, while for clones 191 and 412 the lowest temperatures were obtained. The results show that the clone influences the temperature of the plant cover, which can influence the quality of grass and grapes. A high degree of variation was found for sugar content, from 17.3% (clone ENTAV 15, AN 100) to 25.2% (clone 169, AN 50). The content of total acids expressed as tartaric acid had the lowest values for clone VCR 19 in control treatment (5.2 g/l), and the highest for clone 191 in treatment AN 50 (8.7 g/l). Glycoacidometric index varied from 1.78-4.49.

Keywords: Cabernet Sauvignon, grass cover, ammonium nitrate, quality, grape, thermal imaging



DETERMINATION OF IRRIGATION REGIME IN VINE ORCHARDS IN POVARDARIE REGION OF NORTH MACEDONIA MONITORED WITH QGIS

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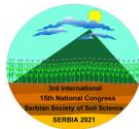
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Abstract

In most parts of the world, cyclonic droughts have a major impact on the amount of water used for irrigation and thus directly on agricultural production. The central part of North Macedonia, i.e. the researched region, is characterized by extremely dry periods during the vegetation, which are further intensified due to climate change. Hence, the need for rational and sustainable use of irrigation water by proper irrigation scheduling and application of proper irrigation techniques are one of the priorities for the region. The field research was conducted in the Povardarie region, and in all 20 soil profiles that were analyzed the Aric Regosol soil type was confirmed. Soil samples were taken from each soil profile for further laboratory analysis. Furthermore, GPS coordinates were taken from each soil profile. The main goal of this research was to determine the irrigation application rate in different irrigation techniques in vine orchards by using soil retention at 0.33, 1, and 6.25 bar. The obtained results were processed using QGIS, which enabled proper monitoring, and in addition through their interpolation (IDW) irrigation water requirements were calculated.

Keywords: irrigation application rate, irrigation water requirements, sustainable use of water, QGIS



Soils for Future under Global Challenges

MINERAL COMPOSITION OF WHEAT GRAINS DEPENDING ON NITROGEN AND ZINC FERTILIZATION

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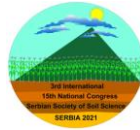
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Abstract

Biofortification of cereals is the main strategy in alleviating the deficiencies of micronutrients in the human diet. The simplest and fastest way to increase the concentration of deficient nutrients in grain is agronomic biofortification, where fertilization increases their concentration in the crop.

The aim of the study was to examine the effect foliar application of zinc sulfate on the concentration of zinc (Zn) in wheat grain and to consider the influence of different doses of nitrogen (N) fertilizers on wheat yield and the content of zinc, iron, manganese and copper in wheat grains. Field experiment was carried out in October 2015 at family farm in Bačka Palanka, Serbia. The experiment was set up as two-factorial. The first factor was wheat cultivar (Graindor and Simonida), while the second factor was fertilization treatments with nitrogen (as ammonium nitrate) and zinc (as zinc sulphate). In both cultivars, the following fertilization treatments were tested: 1. 65 kg N ha⁻¹ applied before sowing; 2. 65 kg N ha⁻¹ applied before sowing and 65 kg N ha⁻¹ applied in spring; 3. 65 kg N ha⁻¹ applied before sowing + foliar application of 1.5 kg Zn ha⁻¹; 4. 65 kg N ha⁻¹ applied before sowing and 65 kg N ha⁻¹ applied in spring + foliar application of 1.5 kg Zn ha⁻¹. Favorable agro-ecological conditions in the experimental year have led to the fact that both wheat cultivars have achieved yields that are significantly higher than the long-term average at the level of the Republic of Serbia. The Graindor cultivar achieved a significantly higher yield and hectoliter weight of wheat grains compared to the Simonida cultivar. At the same time, the yield of wheat did not differ significantly depending on the applied fertilization treatments. Foliar application of zinc sulfate led to a significant increase in the concentration of zinc in wheat grain, whereas the interactions between fertilizer treatment and cultivar were not statistically significant. The increase in zinc concentration in wheat grain due to foliar application of Zn fertilizer was 4.88 mg Zn kg⁻¹ (lower dose of N fertilizer) and 6.46 mg Zn kg⁻¹ (higher dose of N fertilizer), which is expressed as a percentage, increase of 19.62% and 25.71%, respectively. Also, application of zinc and a higher dose of N fertilizer led to a significant increase in iron concentration in wheat grain. On the other hand, fertilization treatments did not affect the manganese and copper concentration in wheat grain. The results suggest that foliar application of zinc sulphate is a suitable method for biofortification of wheat with zinc in our agroecological conditions, and that the application of zinc and nitrogen can have a positive effect on the concentration of iron in wheat grain.

Keywords: biofortification, wheat, yield, fertilization, nitrogen, zinc.



Soils for Future under Global Challenges

COMPARISON OF NDVI AND ARVI VEGETATION INDICES: CASE STUDY IN THE CITY OF BELGRADE, SERBIA

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Abstract

Global climate changes affects plant growth, in the same perspective, rapid and accurate vegetation mapping has gradually become of key importance for monitoring and assessing environmental conditions. Remote sensing includes analysis and interpretation of Earth's surface digital images, that can be obtained from the airspace and aerospace, as well as from the terrain surface. In the last few decades, the possibility of obtaining spatially oriented information by applying remote sensing has drastically increased. Remote detection enables the analysis of plant cover without physical contact with the examined objects and can be applied to large-scale areas. Vegetation indices obtained from the satellite images are simple and efficient algorithms for quantitative and qualitative assessments of vegetation cover, as well as monitoring of plants condition. NDVI (Normalized Difference Vegetation Index) is an indicator of vegetation distribution on a given area, that measures the amount of vegetation through differences between spectral reflections. ARVI (Atmospherically Resistant Vegetation Index) is a vegetation index whose values are prone to changes under the influence of atmospheric factors (rain, fog, smoke, dust, air pollution, etc), and represents corrected NDVI index for the effects of atmospheric scattering in the red reflection spectrum, using measurements in blue wavelengths. Previous researches have determined that in areas with high atmospheric pollution the ARVI index provides better results than the NDVI index. The European Space Agency (ESA) in 2015 has launched a Sentinel-2 mission as part of the Copernicus program, the mission consists of two satellites: A (launched on June 23, 2015) and B (launched on March 7, 2017), which are both equipped with multispectral sensors resolutions from 10 to 60 m that obtaining 13 bands. The data from the Sentinel-2 mission in the non-vegetation and vegetation period were used in this study, for the determination of the NDVI and ARVI indices suitability in urban and rural areas. The study area was the City of Belgrade, the capital of the Republic of Serbia which has a moderate continental climate, that covers 322.268 ha, and includes 10 urban and 7 suburban municipalities. The result obtained with this research displays differences in values between NDVI and ARVI indexes, and their comparison.

Keywords: remote sensing, vegetation indices, NDVI, ARVI, Sentinel-2



EFFECT OF DIGESTATES AND MANURES APPLICATION ON KOHLRABI YIELD AND QUALITY

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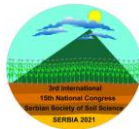
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Abstract

The national action plan for the use of renewable energy sources in Serbia aims to reach much more electricity from alternative sources. Increasing the number of biogas plants will increase the amount of by-products (digestate) obtained, therefore, it is necessary to find their application. The aim of this study was to investigate the effect of digestate application (solid and liquid) on the kohlrabi yield and some quality parameters and compare it with the effect of manure (solid and liquid) and mineral fertilizers application. The experiment was conducted in 2019 on the field used for vegetable production in the vicinity of Novi Sad, Serbia. The experiment was set up as a randomized block design with three replications, with an individual plot of 1.75 m long and 1.20 m wide. Each plot consisted of 32 kohlrabi plants (*Brassica oleracea* var. *gongylodes*). All fertilizers were incorporated into the soil (0-30 cm) 10 days before kohlrabi planting, in the amount which brings 100 kg of N per ha to the soil. The treatments chosen to assess the analyzed parameters were: Ø - control; SD - solid digestate; LD - liquid digestate; SM - solid manure; LM - liquid manure; NPK - mineral fertilizers (100 kg N ha⁻¹ as ammonium nitrate, 80 kg P₂O₅ as superphosphate and 100 kg K₂O as potassium chloride). The application of SD led to a significant increase in the yield of kohlrabi (knobs) compared to all other treatments (Ø; LD; SM; LM; NPK). Also, the application of NPK fertilizers led to a significant increase in yield compared to Ø, LD, SM and LM treatments, while the lowest yield was achieved by LM application. There was no significant effect of all applied treatments on the mass of kohlrabi leaves. The results showed that the application of digestates, manures, and NPK fertilizers did not significantly affect vitamin C (knobs, leaves) and sugar contents (knobs). The content of Zn in kohlrabi knobs was significantly lower with the LM treatment compared to all other treatments, and no significant differences were found between the other treatments. Also, there was no significant difference in the Zn content in kohlrabi leaves depending on the applied treatments. The Fe content in kohlrabi knobs did not differ significantly between treatments, while its content in the leaves was significantly lower with LM and NPK compared to the SD treatment. It can be concluded that the application of digestate has a positive effect on increasing the yield of kohlrabi knobs while maintaining their quality in terms of Fe and Zn, vitamin C and sugar contents.

Keywords: Organic fertilizers, Mineral fertilizers, Kohlrabi quality, Vitamin C



EFFECTS OF APPLICATION METHOD AND TYPE OF MINERAL FERTILIZERS ON ACID SOIL FERTILITY

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Abstract

Strongly acidic soils often represent a limiting factor in the production of most cultivated plants. In such soils, calcification and humidisation measures are generally proposed. Arbitrary application of physiologically acidic fertilizers on strongly acidic soils, further deteriorates the already poor physical and chemical properties of the soil, reduces its fertility, contributes to the reduction of yield and quality of plant products. In order to determine the dynamics and the degree of acidification of the soil with acid fertilizers, the influence of increased doses of NPK and urea on changes in the chemical properties of Dystric Cambisol was studied in a field experiment. The experiment was set up with a raspberry variety Willamette, in the soil of very acid reaction and was monitored for 2 years. In addition to the control (1 t/ha NPK), the experiment contained 4 treatments: 400 kg/ha of urea + 1 t/ha NPK (input throughout the whole plantation), 400 kg/ha of urea + 1t/ha NPK (input in rows), 2t/ha NPK – double dose (input throughout the whole plantation) and 2t/ha NPK – double dose (row input). The application of physiologically acid fertilizers, NPK and urea, and especially their application in the rows, in the first two experimental years did not show the expected acidification reactions of the soil, but had a more alkaline effect. Changes in pH values after treatments were minor and variable due to terrain heterogeneity. Increased uptake of NH_4^+ ions into the soil (derived from NPK and urea) pushed alkaline ions (Ca, Mg and K) from adsorptive complex into the soil solution, which is why their increased content in the soil was measured, especially in the second year of the experiment. The content of available P and mineral N forms, was higher in all treatments compared to the control; the content of mineral N was significantly higher in treatments where fertilizer was introduced into the rows of plantations. Very high to toxic concentrations of mobile Al are significantly reduced in treatment with double dose of NPK-application in rows, as well as in treatment with urea application in rows, in the second year, due to the presence of increased concentration of alkaline ions, primarily Ca and their antagonism with Al. In relation to the control, especially on the treatments with fertilizer application in raspberry rows in the second year, increased concentrations of available microelements Fe, Mn, Zn and B were found. The results obtained in a relatively short period of two years did not show the effect of fertilizers evaluated (NPK and urea) on soil acidification. In contrast, alkaline properties of these fertilisers were detected (primarily, soil concentrations of K^+ , Ca^{2+} , Mg^{2+} were increased, but also and Fe^{3+} and Al^{3+} concentrations). This is probably initial and transient effect of the fertilisers, and decrease and conversation of NH_4^+ in acidic NO_3^- is expected. In order to determine the acidic properties of these fertilizers and their long-term influence on very acid soil fertility, it is necessary to continue the research in the following period.

Keywords: Raspberry, Acid soil, Fertilization, NPK, Urea.



Soils for Future under Global Challenges

FOLIAR APPLICATION OF ZINC IN ALFALFA PRODUCTION

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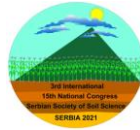
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Abstract

Fodder plants are the most important source of energy for livestock, and in addition, are also a natural source of minerals in the diet of ruminants. In cases of insufficient provision of plants with minerals, several measures can compensate for the lack in the diet of livestock. One of the ways is biofortification, enrichment of plants with microelements through cultivation or using biotechnology. Zinc (Zn) malnutrition in human and animal has been recorded in Serbia and worldwide, and according to this problem, zinc has emerged as an element suitable for the biofortification of staple food and forage crops. In order to investigate the effect of foliar fertilization with Zn and combination of Zn and selenium (Se), on the yield and mineral composition of alfalfa, a field experiment was set up in 2014 in Ljutovo, Subotica. The following treatments were investigated: control without fertilization; 0.5 kg Zn ha⁻¹, 1 kg Zn ha⁻¹, and combination 0.5 kg Zn ha⁻¹ and 10 g Se ha⁻¹. Zinc was applied in the form of zinc sulphate (ZnSO₄ x 7H₂O), selenium in form of sodium selenate (Na₂SeO₄). In average (2014-2015), zinc foliar application did not affect the fresh and dry yield of alfalfa and the content of P, K, Cu, Fe, and Mn. As expected, Zn fertilization increased its content in dry matter of alfalfa. The increase was greater in the first year of experiment as less alfalfa biomass was achieved. Data analysis showed that in 2014, by applying 0.1 kg of Zn ha⁻¹, the Zn content in the plant increased by 34.32 mg of Zn kg⁻¹, in contrast to 2015 when increase was 7.8 mg Zn kg⁻¹. The efficiency of Zn uptake by alfalfa biomass slightly decreased with increasing Zn dose. No negative effect on the Zn content in the plants was found on treatment with Zn and Se in combination. In the first year of the experiment, a significantly higher Zn content (29 mg kg⁻¹) was measured on this treatment compared to the treatment without fertilization (16 mg kg⁻¹). Fertilization with Se and Zn in combination could be recommended because the expected antagonism between selenates and sulphates during Zn uptake has not been established. Since foliar fertilization of alfalfa with Zn did not lead to a decrease in yield and led to a higher Zn content in the feed, the application of this element in alfalfa cultivation can be an important measure for improving the Zn status in cattle. Also, higher doses of Zn fertilizers should be investigated in order to achieve higher Zn content in plants in favourable years with greater yields.

Keywords: biofortification, forage crops, yield, microelements.



Soils for Future under Global Challenges

MICROGRANULATES AND BIOSTIMULANTS AS ALTERNATIVES TO DIAMMONIUM PHOSPHATE FERTILIZER IN MAIZE PRODUCTION ON MARSHLAND SOILS IN NORTHWEST GERMANY

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Abstract

Because of eutrophication of surface and groundwater systems, and with regard to limited global reserves of phosphorus (P) for conventional fertilizer production, new fertilizing systems have to be established in crop production. This study was conducted to evaluate the application of P-reduced mineral fertilizer alone or in combination with biostimulants as alternatives to wide spread DAP-fertilization (Diammonium Phosphate) in maize (*Zea mays*) on a marshland soil site. Experiments were carried out as field trial with 22 parcels each repeated 5 times during past three years (2018–2020) in northwest Germany.

Treatments were realized as combination of two mineral fertilizers, viz. DAP or a P-reduced microgranulate depot-fertilizer (Startec) and the biostimulants mycorrhiza, humic substances and soil bacteria single or in parallel application with two or three of the mentioned biostimulants. Also, mineral fertilizer variants have been single tested without additional biostimulant.

Every fourth parcel has been used as control, only treated with biogas slurry, to identify site-specific spatial variability and to implement correction factors within the raw data using standardized methods. Startec performs as good as DAP in both, yield and corn cob ratio, while P-balance is better ($av = 4.5 \text{ kg P}_2\text{O}_5/\text{ha}$) in parcels with Startec compared to DAP ($av = 43.7 \text{ kg P}_2\text{O}_5/\text{ha}$). No crucial differences between the treatments were present in nitrogen application due to small differences in N-content of the two chosen mineral fertilizers. Single and multiple combination of biostimulants resulted only in non-significant higher yield in average, with the exception of the combination between soil bacteria and mycorrhiza in combination with DAP. In the latter combination, the rise in yield has been significant. In general, the low positive effect of biostimulants on DAP-fertilized sites is higher than the effect on Startec-fertilized sites. The corn cob ratio did not change over the variants with and without biostimulants.

These results suggest a limited potential of biostimulants on soils rich in P, humus and water. An adequate alternative to DAP in both aspects - ecological and economic - on fertile marshland soils has been found in the P-reduced microgranulate fertilizer Startec.

Keywords: diammonium phosphate, eutrophication, P balance, biostimulants, humic substances, mycorrhiza, soil bacteria, microgranulate



WATER REQUIREMENTS OF FRUIT AND VINE PLANTATIONS IN THE AREA OF THE KOLUBARA DISTRICT IN PRESENT AND FUTURE CLIMATE CONDITIONS

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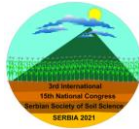
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Abstract

Fruit and vine production in the territory of the Kolubara District encompasses 15,685 ha, which accounts for around 15.3% of the total plant production. When it comes to fruit plantations, plums are the most represented (70%), while peaches and strawberries account for only 0.3%. The aim of this research was to determine the seasonal water requirements of fruit trees in climate change condition, to find out whether there will be changes in irrigation requirement. In addition, the paper includes the analysis of water requirements for the future periods in order to enable producers to adapt their agronomy practices and growing systems to the forthcoming conditions. FAO methodology (FAO Irrigation and Drainage Paper No. 56), was used to estimate the evapotranspiration, effective precipitation, crop evapotranspiration and water deficit, for 8 groups of fruit plantations: (I) apples, pears, plums, quinces, walnuts and hazels – the orchard without grass cover; (II) apples, pears, plums, quinces, walnuts and hazels – grassy orchard; (III) apricots and peaches – the orchard without grass cover; (IV) apricots and peaches – grassy orchard; (V) sweet cherries and sour cherries - the orchard without grass cover; (VI) sweet cherries and sour cherries - grassy orchard; (VII) strawberries, raspberries, blackberries and blueberries and (VIII) grapevine. The fruit plantations were categorised into the above-mentioned eight groups according to the length of the vegetation period and the crop coefficient values. The observed period from 2000–2019 and two future periods (2021–2040 and 2041–2060) were analysed. The climate data for the reference 2000–2019 period were obtained from the meteorological station in Valjevo. Data for the future climate were obtained using 8 climate models for the RCP 8.5 climate scenario. The paper provides the results obtained as the median of the calculations for eight climate models. The evapotranspiration value varies from 438.6, 429.0 and 440.5 mm for fruit trees from group V, respectively, to 892.2, 857.5 and 884.6 mm for fruit trees belonging to group II, with the average values of 596, 577.9 and 595.4 mm for the reference period, the future 2021–2040 and 2041–2060 periods, respectively. The seasonal water deficit varies from 88.0, 41.3, and 90.6 mm for grapevine (group VIII) to 405.6, 352.3, and 405.3 mm for fruit trees from group II, with the average values of 224.4, 198.7 and 245.3 mm for the reference period, and future 2021–2040 and 2041–2060 periods, respectively. The results of this research indicate that no significant differences in the water requirements between the future periods and the reference period.

Keywords: water deficit, fruit plantations, climate conditions



Soils for Future under Global Challenges

GROWTH CONTROL AND FRUIT QUALITY OF APPLE CULTIVAR ‘GALA SCHNIGA’ USING ROOT PRUNING TECHNIQUE

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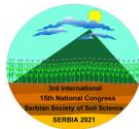
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Abstract

The aim of this study was to evaluate influence of different level intensity of root pruning on vigour and fruit quality of apple cultivars 'Gala Shniga'. Root pruning was done two weeks before buds burst, on one (RP1) and both side of rows (RP2), at a distance of 30 cm from the trunk and depth of 40 cm. The study included the following vegetative properties: stem diameter, trunk cross-sectional area, number and length of young shoots, number and length of internodes, while generative traits were included following a number of flowers buds per tree, a number of fruits per tree, return blooming, yield, the mass of fruit, a diameter of fruit, percentage of colored of fruits. A non pruning rootstock tree was as control. The highest values of total length and number of shoots were found in control trees. The value of TCSA was between 46.9 cm² to 57.0 cm², and the highest annual increase of TCSA had control trees (22.3%). Light root pruning (RP1) did not reduce the mass and diameter of fruits compared to control trees. The techniques of root pruning had significant effects on yield of the cultivar 'Gala Schniga'. The highest yield had trees in the RP1 treatment (29.2 kg), while control trees had the smallest (22.5 kg). The percentage of marketable fruits was higher in control trees compared to treated trees. The highest content of total soluble solids was found in fruits from treatment 2, while control trees had the lowest. Root pruning had strong influence to decreasing vigour of trees. So, moderate root pruning techniques at the end of the winter period could be recommended for successful control of vegetative growth and improved generative properties.

Keywords: apple, root pruning, vigour, yield, fruits quality.



Soils for Future under Global Challenges

EMERGENCE AND INITIAL GROWTH OF *ALLIUM URSINUM* IN DIFFERENT SOIL TYPES

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Abstract

In order to define the optimal soil conditions for the growth of bear onion (*Allium ursinum*), in September 2020, field experiment was established. The aim was to determine the influence of 4 different soil types on the growth and development of the aboveground part of the medicinal plant species *A. ursinum*. The experiment was performed in a plastic container measuring 40x12x15 cm, and the containers were filled with 4 soil types: Arenosol, Fluvisol, Cambisol and Chernozem, with each type containing 4 containers. Prior to planting into the containers, reproductive material of *A. ursinum* (bulbs) was collected from the locality Ležimir ("45 °07'40.0" N 19 ° 31'57.2 "E"). For planting, 160 healthy and uniform bulbs were selected. In each container, 10 bulbs were planted at depth of 10 cm. After planting, containers were placed in the shade and buried in the soil to a depth of 15 cm. Monitoring of plant growth and development began at the end of March 2021 by counting sprouted plants and measuring leaf weight. The highest average number of sprouted plants (9.25) and the highest average leaf weight (0.78 g) were obtained by growing bear onion in Chernozem. In Arenosol, the average number of sprouted plants was 2.75 with an average leaf weight of 0.40 g, while in fluvisol the average number of sprouted plants was 4 with average leaf weight of 0.45 g. Plants grown in Cambisol were slightly better than plants grown in arenosol and fluvisol, but still lower than in Chernozem soil. The average number of sprouted plants grown in cambisol was 9, and the average weight of the leaves was 0.73 g. Preliminary results showed that Chernozem and Cambisol could be suitable soil types for domestication and introduction of this medicinal plant species.

Keywords: Arenosol, Fluvisol, Cambisol, Chernozem, *Allium ursinum*.

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INFLUENCE OF MYCORRHIZAL FUNGI ON *Satureja montana* L. GROWN IN CHERNOZEM AND ARENOSOL

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Abstract

Satureja montana L. is a valuable perennial medicinal and aromatic plant belonging to *Lamiaceae* family. In this paper, the effects of mycorrhizal fungi (combination of *Glomus mosseae* and *G. intraradices*) were studied in a pot experiment in field conditions. Winter savory plants were grown in low carbonate Chernozem with high clay content and typical Arenosol with low plant-available phosphorus determined in both soil types. It is known that mycorrhizal fungi can improve the phosphorus nutrition of plants under phosphorus limiting conditions, enhance plant growth, and increases the yield of crop plants. Prior to the pot experiment made in a field, the winter savory was vegetatively propagated by softwood cuttings. Rooted cuttings were transplanted into 1.5 L plastic pots (one plant per pot) filled with Chernozem and Arenosol taken from the plow layer of the soils in a disturbed condition. The experiment was set in a split-plot design with 4 replications. The main plots were soil types, while sub-plots were 2 treatments (inoculated and non-inoculated plants) with 6 pots in a random arrangement in each repetition. Plants were watered regularly with an installed drip irrigation system and weeds were regularly removed. After 90 days, non-inoculated and inoculated plants were harvested and the stems and leaves absolute dry masses were determined. Inoculated plants in both soil types had higher stems and leaves absolute dry masses compared to non-inoculated plants. The stems and leaves absolute dry masses of inoculated plants in Chernozem and Arenosol were 0.75 ± 0.21 and 0.58 ± 0.10 g, while for non-inoculated plants were 0.18 ± 0.06 and 0.36 ± 0.09 g, respectively. Results indicate that Arenosol could be a potentially suitable soil type for introduction and domestication of this medicinal plant species since the growth of pot winter savory plants in Arenosol is proven to be better concerning non-inoculated plants in Chernozem. Further research on the possible introduction and domestication of winter savory to the Arenosol soil type should be conducted in the future.

Keywords: Arenosol, Chernozem, winter savory, mycorrhizal fungi

This study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia; Evidence number: 451-03-9/2021-14/200003.



PREDICTION OF SOIL TEMPERATURE BY AIR TEMPERATURE: A CASE STUDY FOR RIMSKI ŠANČEVI

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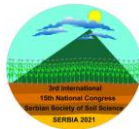
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Abstract

Soil temperature is a very important parameter that affects agronomic, climatological and hydrological processes. The microbiological and biological processes that affect the physiological growth and development of plants, pest growth, as well as the speed and amount of evaporation, the speed of snow melting, etc. depend on soil temperature. Knowing the soil temperature, in the depth in which the root system extends, would help in making decisions on the time of sowing, i.e. planting, in the fight against pests, etc. However, soil temperature data are often inaccessible to farmers, primarily due to the high cost of thermometers, as well as the complicated installation procedure, which requires training and technical expertise. The aim of this paper is to show how the soil temperature can be estimated based on the measured air temperature data, which are more accessible. The research included the measurements of air temperature and soil temperature at the Rimski Šančevi meteorological station in the period 1993-2019. The soil on which the measurements were made is carbonate chernozem on a loess terrace (0-60 cm loam; 60-100 cm clay loam). A regression and correlation analysis of the measured mean daily air temperatures and mean daily soil temperatures in the period 1993-2013 was performed at the depths of 5, 10, 20, 30, 50 and 100 cm. After that, the estimated values of soil temperature (at all mentioned depths) for the period 2014-2019 were verified. The results showed that up to a depth of 50 cm, soil temperature shows a very high correlation with air temperature, with the dependence decreasing slightly with depth. The values of the coefficient of determination R^2 at the depths of 5, 10, 20, 30 and 50 cm, respectively, are: 0.94, 0.93, 0.90 and 0.86 ($p < 0.0001$). At 100 cm of soil depth, the dependence of soil temperature on air temperature is lower, but in the range of high dependence ($R^2 = 0.67$) ($p < 0.0001$). Testing of regression equations in all six years (2014-2019) showed a very good agreement between the estimated and measured values of soil temperature at all depths, but the agreement decreased slightly with the increase in depth. The average correlation coefficient (Pearson distribution) for the six tested years, at the depths of 5, 10, 20, 30 and 50 cm, shows a very high correlation (0.969, 0.966, 0.954, 0.926 and 0.904, respectively), and at a depth of 100 cm shows a high correlation (0.820).

It can be concluded that by applying the obtained regression equations, it is possible to estimate the temperature of the loamy soil, with great reliability, at different depths, on the basis of air temperature data.

Keywords: soil temperature, air temperature, correlation



PROJECTION OF THE WATER REGIME PARAMETERS OF ZEMUN CHERNOZEM FOR WINTER WHEAT PRODUCTION BY THE END OF THE 21ST CENTURY

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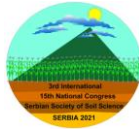
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Abstract

This paper presents the projection of the water regime parameters of the Chernozem soil under winter wheat crops in the region of Zemun (Serbia) from 2021/2022 to 2099/2100. The average values of the simulated parameters in the near (2021/2022-2050/2051) and distant future (2070/2071-2099/2100) were compared with the values of the simulated parameters from the reference period (1970/1971-1999/2000). The projection of climate parameters was made under the assumption that no mitigation measures for greenhouse gas emissions would be implemented in the future (RCP8.5). Air temperature (T_{\min} , T_{\max} and T_{mean}) and effective rainfall were simulated using a climate model. The projection of the water regime parameters of Chernozem was obtained using the FAO CROPWAT 8.0 crop model. A simulation of the following soil water regime parameters was performed: potential winter wheat evapotranspiration (ETc), actual winter wheat evapotranspiration (ETa), winter wheat irrigation water requirement and yield reduction in relation to the genetic yield potential. The results of the climate model indicate that by the end of 2100 air temperature will have increased in the region of Zemun in the winter wheat growing season (October 16th – June 22nd). The projections indicate a T_{mean} increase of 2.6 °C in the near future, and 5.2 °C in the distant future, relative to the reference period. The projected precipitation amounts (October-June) indicate that precipitation is expected to increase by 5% in the near future and 3% in the distant future, in relation to the reference period. The crop model simulations indicate that, compared to the reference period, Chernozem water regime conditions for the winter wheat production are expected to be more favourable in the near future. It is expected that ETc and ETa would increase (by 4% and 3% respectively), that the irrigation water requirements would decrease (-7%) and that yield reduction would decline compared to the reference period. Contrary to the projections for the near future, in the last three decades of this century (distant future), Chernozem water regime conditions for the production of winter wheat are expected to be less favourable than the conditions so far. ETc is expected to increase (by 3%), ETa to remain unchanged, the irrigation water requirements to increase (by 12%) and yield reduction to get higher compared to the reference period.

Keywords: climate change, winter wheat, water requirements, irrigation water requirements, yield reduction, CROPWAT



THE ISSUE ABOUT FERTILIZER RECOMMENDATION IN APPLE ORCHARDS IN NORWAY

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Abstract

In the last few decades a modernization of apple production in Norway led to the planting of new high density orchards with modern international cultivars which replaced traditional ones. However, fertilization practice for apple orchard management is not standardized, meaning that farmers applied fertilizer according to their own assumption. In the meantime, some coordination between farmers and scientifically controlled fertilizer input existed by using fertilizer recommending by Norwegian Institute of Bioeconomy Research (NIBIO) and Norwegian University of Life Science (NMBU), while Norwegian Agricultural Extension Service (NLR) also took part in farmer advising. At the same time, another commercial assistance to farmers existed by EUROFINS testing company which has its own soil test interpretations. Norwegian farmers also could count on the national fertilizer producer “Yara”, which provided recommendations of fertilizer application to various crops including apples (“Yara apple program”). In most Norwegian apple orchards, the amount of added nitrogen through the season is about 40-75 kg/ha, maximum 90 kg/ha, while the average amount of phosphorous varied round 10-20 kg/ha, and potassium input is between 35–75 kg/ha. The main reason for such limited nutrient supply is a richness of orchard soils with organic matter (5-8%) which under the Mesic climatic conditions create the availability of nitrogen. In the past EUROFINS and NMBU/NIBIO soil analysis reports was calculated N as a “total N” without precise interpretation guide, and without the quantity of available forms of nitrogen (NH_4^+ and NO_3^-) in the soil. Only the recommendation of “Yara” company gave an exact content of N that apple tree needs. According to the present situation, TERREPLE project deals with a large number of orchards’ soil samples from different locations in Norway that are already submitted for the incubation process in order to explore a degree of mineralization under different condition. These results will also include a climatic variation (temperature, leaching, moisture, etc.), which will serve as a correction factor for obtained results. This could give a basic and exact data about the soil N potential which is available for apple fruit trees. Besides N, these results will include also a phosphorous potential, concerning its most presence in soil in organic form, which is applied in Norway apple orchards only in minor quantities. The key problem for potassium in Norway apple production, which is greatly dependent on this element, is that soil organic matter reserves are not considered as a reservoir of this element, when K should be applied by fertilizers. Therefore, its available presence in tested soil varied between low or extremely high, so, a K fertilizer recommendation should balance this polarity in Norway orchards.

Keywords: apple, organic matter, nitrogen, phosphorous, potassium



Soils for Future under Global Challenges

NATURAL CHARACTERISTICS OF THE GACKO AREA

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Abstract

Uncontrolled utilization of land by technical stakeholders leads to permanent loss of it. Such processes further reduce already limited areas for plant production. The Gacko basin is located in the Gacko field in the southeastern part of the Republic of Srpska. The Gacko field is a typical karstic field that drains through the sink. The climate of the Gacko region is continental-mountainous. On limestones in Gacko area are formed Organo–mineral fertile Soils, Brown soils on the limestones and Ilimerized Soils. In the recent past, there were areas under barley, rye and oats, whereas today these areas are used mostly for grazing. Forests of beech and fir are represented, but without spruce, secondary beech forests. The use of land in the Gacko area has an emphasized extensive character, with expressed tendencies of insufficiently planned and irrational approach. Land losses are caused primarily by unplanned construction of residential, industrial and infrastructure facilities, irrational exploitation of mineral resources, excessive erosion caused by deforestation, and irregular handling on slopes.

Keywords: Gacko area, soils, natural characteristics



Soils for Future under Global Challenges

A COMPARISON OF FIVE METHODS FOR REFERENCE EVAPOTRANSPIRATION ESTIMATION IN THE WEST, CENTRAL, EASTERN, AND SOUTHERN SERBIA

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Abstract

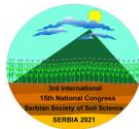
Current climate conditions are often characterized by frequent water shortage during periods when plants are most sensitive to drought stress. Soil moisture plays a key role in pedogenic processes as well as in supplying plants with water. Therefore, it is necessary to determine crop water requirements for the irrigation systems design and to organize adequate irrigation scheduling. The International Commission on Irrigation & Drainage (ICID) and the Food and Agriculture Organization of the UN (FAO) deem the Penman-Monteith method (FAO56-PM) as the most suitable for estimating reference evapotranspiration (ET_0). Reference evapotranspiration depends on climate parameters such as air temperature and humidity, wind speed, and net radiation but also on geographical factors which describe the position of a certain site – latitude and elevation. However, due to the lack of climate data, alternative methods for calculating evapotranspiration in specific areas have been developed. This research aims to assess the possibility for the application of several ET_0 methods in the climate conditions of West, Central, Eastern, and Southern Serbia. Hargreaves, adjusted Hargreaves, Turc, and Jensen-Haise method were compared with the Penman-Monteith which was the referent method in this study. The meteorological data used in this research were monthly data (2000-2019) collected from 17 representative meteorological stations at a district scale. The methods were compared using mean absolute error (MAE). Turc and the adjusted Hargreaves method showed the lowest deviation from the reference (MAE=0.08 mm·day⁻¹, 0.14 mm·day⁻¹ respectfully), while the Hargreaves method had shown the highest deviation (MAE=0.74 mm·day⁻¹). Generally, the lowest deviation was obtained for the Bor, Mačva, and Kolubara districts (0.23 mm·day⁻¹, 0.26 mm·day⁻¹ and 0.29 mm·day⁻¹ respectively). Turc method had shown the lowest deviation in the Toplica district, while Hargreaves deviated the most. The results of the research indicate that the adjusted Hargreaves and Turc methods can be used to calculate ET_0 in case of missing data. The adjusted Hargreaves is the most reliable in almost all districts, although it utilizes only air temperature data.

Keywords: reference evapotranspiration, FAO56-PM, method comparison, Turc, Hargreaves, adjusted Hargreaves, Jensen-Haise



Soils for Future under Global Challenges

SECTION 3: SOIL DEGRADATION AND SOIL AND WATER CONSERVATION



CHANGES OF THE SOIL ENVIRONMENT AFFECTED BY FLY ASH DUMPING SITE OF THE ELECTRIC POWER PLANT

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Abstract

The natural environment can be degraded and the diversity of ecosystems can be reduced, although changes may not be visible to the naked eye. This is the case in the vicinity of lignite-fired power plants, where the furnace waste collected in the dumping site is blown out as alkaline fly ash. If the impact lasts only several dozen years, changes in vegetation are not visible, while change in the soil environment is noticeable, especially when it concerns forest soils. As a result, the pH of the soil surface horizons changes drastically, affecting the soil forming processes. The investigation deals with Podzol derived from sand in direct vicinity of the dumping site (50 m) of Bełchatów power plant (central Poland), as well as in control area (8 km away). Apart of the neutralization of the ectohumus horizon, the impact of the landfill was also noted in the changes of the soil morphology. As a result of the alkalization, Es horizon were transformed into AEs horizon, and Bhs horizon has been converted into a Bs horizon. Chemical and spectroscopic properties (fluorescence, UV-Vis) of humic substances from ectohumus horizon indicated that originally present humic substances have a lower degree of humification, characterized by a looser structure, than those existed in soils affected by fly ash. The neutralization of the soil reaction resulting from the deposition of fly ash favored the formation of humic and fulvic acids with a more complex structure, characterized by a higher concentration of aromatic rings in the core of the molecule and the presence of double conjugated bonds. Leaching of low molecular humus fraction – typical for Podzols – has been minimized as a result of pH changes caused by the impact of the landfill. Instead mechanical translocation of organic matter contributed to formation of AEs horizon, while originally occurring humic substances in the Bhs horizon (present in the control profiles) have been probably transported out of the soil profile and then into the groundwater.

Keywords: humic substances, alkalization of Podzol, fluorescence, ectohumus horizon



Soils for Future under Global Challenges

FTIR SPECTROSCOPIC STUDY OF S-METOLACHLOR SORPTION ON INORGANIC AND ORGANICALLY MODIFIED MONTMORILLONITE FROM BOGOVINA

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Abstract

Environmental problems related to the use of herbicides are a causing concern due to their increasing presence in soil, groundwater and surface water. Numerous methods are developed in order to reduce herbicide mobility and protect natural water resources. The results presented in this paper show the interaction of herbicide S-metolachlor with inorganic and organically modified montmorillonite from Bogovina (Boljevac municipality, Serbia). Clay sample from Bogovina represent Ca-Na montmorillonite with a small amount of quartz, cristobalite and carbonate minerals. Organic montmorillonites were obtained after modification with different concentrations of organic complex (HDTMA and PTMA), whereas inorganic modification was performed with 1M NaCl solution. The interaction between minerals and herbicide was monitored using infrared spectroscopy.

IR bands observed in the inorganic modified montmorillonite (Na-montmorillonite) are typical for smectites with a high Al content in the octahedron position.

The intercalation of HDTMA⁺ cations into the interlayer space produces redshift of the IR bands that originate from the vibrations of the adsorbed water, as a consequence of the reduction of the hydrogen bond strength in HDTMA-montmorillonite. Also, the intensity of these bands decreases significantly with increasing concentration of HDTMA⁺ cation. All these changes are related to the decreasing of the water content in the interlayer space by increasing the content of HDTMA. The occurrence of the stretching CH₂ vibrations is generally the main difference in the spectrum of HDTMA modified montmorillonite in comparison with the spectrum of inorganically modified montmorillonite. The wavenumber, intensity and width of these bands are sensitive to conformation in hydrocarbon chains.

On the other hand, after the organic modification of the montmorillonite with the PTMA complex, stretching vibrations of phenyl ring occur.

Analysis of FTIR spectroscopy data showed that the hydrogen bond is one of the most important mechanisms that occur between Na-montmorillonite and S-metolachlor. Comparing the FTIR spectra of herbicides before and after the sorption, it can be concluded that carbonyl group participate in the binding process.

Sorption of S-metolachlor on HDTMA-montmorillonites causes the redshift of the C = O absorption band. Shifting to lower wavenumbers and joining with the deformation vibration band of water indicates that the C = O group participated in the formation of a bond with the montmorillonite.

Sorption of S-metolachlor molecules on PTMA-montmorillonite takes place through the interaction between the aromatic benzene ring of S-metolachlor and the aromatic benzene ring of the organic complex (π - π bonds). Also, the formation of a hydrogen bond occurs between the molecules of S-metolachlor and the molecules of water that are in the interlayer space and/or oxygen on the surface of the tetrahedral sheet of the montmorillonite.

Keywords: adsorption, S-metolachlor, HDTMA, PTMA, infrared spectroscopy



THE IMPACT OF AGRICULTURE ON THE GLEYSOL AND FLUVISOL SOILS: CASE STUDY IN PODRAVINA REGION, CROATIA

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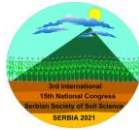
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Abstract

Soil contamination with potentially toxic metals (PTMs) in the agricultural areas developed on open aquifer systems can be an environmental problem. The subject of this study is Gleysol and Fluvisol in the area of Podravina region, NE Croatia. The aim of this research was to determine the geochemical and mineralogical soil properties and accumulation or mobilisation of PTMs in Gleysol and Fluvisol under agricultural activities, and their possible influence on the shallow groundwater developed at the locations Kalinovac-Hrastova Greda and Podravske Sesvete. Within each of the soil types samples were collected to a depth of 200 cm with an Eijkelkamp auger set for soils. Samples were obtained from 0-20 cm, 20-40 cm, 40-70 cm, and 70-100 cm depth in Gleysol; and from 0-40 cm, 40-70 cm, 70-100 cm, 100-140 cm, 140-170 cm, and 170-200 cm depth in Fluvisol, based on visible macrofeatures and field estimation of the granulometric and mineralogical changes along sampling depth of each soil type. The laboratory analysis of soil samples includes: pH, electrical conductivity (EC), soil texture, cation exchange capacity (CEC), sequential extraction analysis (BCR) of: As, Cu, Zn and Cd, and mineralogical analysis using X-ray diffraction (XRD). The sequential extraction analysis was performed according to the BCR procedure and proportions of elements were determined in four fractions: (1) carbonate (CARB), (2) the fraction of Fe-Mn oxyhydroxides (FEMN), (3) organic-sulphide (OR/SUL), and (4) residual fraction (RES). The Gleysol is slightly acidic in the upper 70 cm soil, while it is considerably acidic at the 70-100 cm depth. In the case of Fluvisol, pH is slightly acidic throughout the entire thickness of soil. Soil texture in Gleysol is silt loam, while in Fluvisol it is sandy silty loam. CEC is in line with soil texture for both analyzed soils. XRD analysis on fraction less than 2 μm showed that major mineral phases in Gleysol are goethite and vermiculites, smectites, while Fluvisol mostly consists of chlorites, kaolinites, vermiculites and smectites. The maximum As concentration in Gleysol is 526 mg/kg, which is determined in the topsoil (0-20 cm) in RES fraction. After RES, the OR/SUL fraction is the next most represented. The same trend is found for Zn and Cu in Gleysols. The maximum As concentration in Fluvisol is 75 mg/kg, which is determined in the topsoil (0-40 cm) in RES fraction, while FEMN fraction is the next most represented. The concentration of other analysed metals (Zn and Cu) increase with soil depths for all fractions. Cadmium is not detected in investigated soils. It can be concluded that in the case of Gleysol, influence of agricultural activities is recognized, with the effect decreasing PTMs concentration after approximately 70 cm depth, which is not similar for Fluvisol except for As.

Keywords: potentially toxic metals, Gleysol, Fluvisol, soil mineralogy



Soils for Future under Global Challenges

SOIL TYPES AND THEIR SENSITIVITY TO THE ACIDIFICATION PROCESS IN THE MUNICIPALITIES OF KOSJERIĆ, POŽEGA AND UŽICE

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Abstract

The acidification process can be considered as main cause of reduced productivity of agricultural soil, which in the previous period was significantly accelerated by anthropogenic factors, primarily increased emissions and deposits of acidic pollutants and inadequate use of mineral fertilizers (Sparks, 2002). The degree of sensitivity of the soil to the acidification process is defined by the buffer capacity of the soil, that is, its physical and chemical properties. Accordingly, 20 soil profiles were opened at the study area and 60 soil samples were taken for laboratory analyses (7 profiles in the municipality of Kosjerić, 9 profiles in the municipality of Požega and 4 profiles in the municipality of Užice). According to the criteria of the national classification (Škorić et al., 1985), 9 types of soils are defined as: Haplic Fluvisol, Haplic Vertisol, Leptic Calcisol, Mollic Umbrisol, Haplic Cambisol (Eutric), Haplic Cambisol (Dystric), Leptic Cambisol, Luvisol and Haplic Planosol. An analysis of the trend of sulfur (S) and nitrogen (N) deposition for the period 1980-2015 was performed, as well as analyzes of soil sensitivity to the acidification process by the following methods: Holowaychuk & Fessenden (1987) (CEC and pH in H₂O combined with soil sensitivity to base loss, acidification process and aluminum solubility result in overall sensitivity) and Kuylenstierna (2001) (BS and CEC are included as a criterion of soil sensitivity). For geospatial distribution preview of different sensitivity classes Cinderby (1998) method was applied. Sensitivity classes are defined regarding different soil buffer ranges and buffering mechanisms, weathering of different minerals, base saturation and cation exchange. Soil types characterised with BS=80-100% are in the carbonate buffer range and BS=0-20% are likely to exist in the aluminium buffer range. Sensitivity classes were determined for each soil type according to measured CEC and BS and ISRIC soil database defined sensitivity classes (FAO, 1974). Results are showing the percentage of dominant soil types of the study area, respecting buffer abilities and the sensitivity to acidification. Leptic Calcisol, Haplic Fluvisol and Haplic Cambisol (Eutric) and Leptic Cambisol belonging to the classes of low sensitivity and very low sensitivity to the acidification process (class IV and V) are distributed along the perimeter of the study area. More than 65% of the area belongs to the class of very low sensitivity to the acidification process (class V), and 16.10% to the class of low sensitivity (class IV). In some places, in the northwest, southeast and central part of the studied area, there is Haplic Leptosol, which is classified in the II class of sensitivity to the acidification process. More than 16% of the areas in the municipalities of Kosjerić, Požega and Užice belong to this category of sensitivity. In the upper part of the course of the river Đetinja, soil types with sensitivity category I are represented and occupy 2.32% of the area.

Keywords: acidification process, degree of sensitivity, cation exchange capacity, soil types, Kosjerić, Požega, Užice



Soils for Future under Global Challenges

THE IMPACT OF TAILING OUTFLOW ON THE AVAILABILITY OF POTENTIALLY TOXIC ELEMENTS (Zn, Cu, Pb, Cd) IN SOILS NEAR TO FORMER MINE STOLICE (SERBIA)

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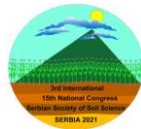
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Abstract

This paper shows the impact of the tailing outflow on the availability of potentially toxic elements (PTEs - Zn, Cu, Pb, Cd) in the soils in Korenita river catchment (west Serbia). A tailing dump of the former mine Stolice is located in the Korenita river catchment, from which outflow more than 100.000 m³ of sludge in the 2014 flood accident. As a result of the accident, these soils can become contaminated by the heavy metals and metalloids, and bioavailable with possible ecological risk to plants. The aim of the paper was to determine the total content of Zn, Cu, Pb and Cd in flooded soils, as well as their availability to plants and possible ecological risk. Soil samples were taken by fixed depth from the open pedological profiles, in order to determine soil properties, the total content of PTEs (potentially toxic elements) in aqua regia, and available forms (in 1M ammonium acetate). The extraction by 1M ammonium acetate was used to determine easily soluble forms of the elements (BBodSchV 1999 - German Federal Soil Protection and Contaminated Sites Ordinance), which are mostly available to plants. The total content of Zn, Pb and Cd in flooded soils are statistically significantly higher in all studied topsoil layers (0-20cm) than in non flooded soils, with the mean values higher than the maximum permissible concentration (MPC) (Official gazette 30/2018). The contents of Cu in all soils are lower than MPC, but in the layer of 0-10cm, the content of Cu in flooded soils is statistically significantly higher than in unflooded soil. The available forms of Zn, Pb and Cd are statistically significantly higher in flooded soils, and are higher or around the MPC. The available forms of Cu are not statistically significantly different between flooded and unflooded soils, and are lower than MPC. Statistically significant difference was determined between available forms Pb – Zn (0,442*), Zn – Cd (0,682**) and Cd – Pb (0,554**), indicating their common origin from the tailing material. On the other hand, Cu has no correlation with other elements. pH values of flooded soils are in a range of 7,3 – 8,2 affecting lower available forms of Zn, Pb and Cd. The extracted available forms refer only to cationic forms and still contribute to the knowledge of the soil contamination in the catchment of Korenita River.

Keywords: availability of potentially toxic elements, ammonium nitrate, tailing, flooded soil



Soils for Future under Global Challenges

THE IMPORTANCE OF SOIL DATA UNIFICATION FROM SERBIAN AGRICULTURAL ADVISORY SERVICE AND ACCOMPANYING PROBLEMS

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Abstract

A huge amount of soil data represents potentially useful information for soil mapping. Therefore, in many parts of the world, great efforts are being made to preserve, harmonize and use the data acquired in the previous period. Problem occurs when original data are burdened with various errors that occurred during their collection and digitization. In order to make them useful, unification of data is required. The purpose of this study was to make the base for large scale territory mapping. Therefore, 1,200,000 soil data obtained from 200,000 soil samples, from Agricultural advisory services of the Republic of Serbia, (AASS) were harmonized and used for mapping the territory of Central Serbia. The coordinate system or projection is considered as the main parameter according to unification was done. The main obstacles during unification were in sorting over five different coordinate systems per file, aligning headers, rows and columns that will be converted to CSV format to load data into GIS mapping software. Only after unification, vector and raster layers were created, merged and compared to other sources. Maps show the distribution of seven soil properties: pH in water, pH in KCl, CaCO₃, soil organic matter (SOM), total N, P₂O₅ and K₂O. These maps (data) compared with the future maps could contribute an insight into the balance of nutrients and SOM, providing information on further tendencies - degradation or enrichment of soil at the state level. Mapping the soil properties over a large-scale territory is important for planning the type and amount of fertilization distribution, amelioration strategies and regionalization in agriculture. Also, with a provided data on the map, we can easily notice parts of the territory where data/analysis is missing and therefore influence additional field and laboratory research in order to obtain more accurate information, which will help the rational use of soil resources. Thus, it is necessary to point out the lack of a protocol for collecting soil data which makes it difficult to enter the obtained data and calls into question their correctness. Adherence to the defined protocol would facilitate the entry of all collected data into a single soil database, which would provide a powerful tool for various spatial analyses of soils in Serbia. Solutions that would contribute to all of the above is that all AASS use one coordinate system or projection when sampling and use same methodology in soil analyses.

Keywords: GIS, AASS, mapping



Soils for Future under Global Challenges

UNCERTAINTY OF SOILGRIDS TESTED ON 1 200 000 SOIL DATA FROM NATIONAL SOIL FERTILITY CONTROL

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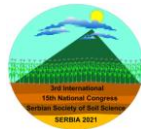
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Abstract

SoilGrids is a system for digital soil mapping based on a global compilation of soil profile data (WoSIS) and environmental layers. SoilGrids provides global predictions for standard numeric soil properties (soil organic carbon (SOC), bulk density, cation exchange capacity (CEC), pH, soil texture fractions, and coarse fragments) at seven standard depths (0, 5, 15, 30, 60, 100, and 200 cm). For this study, accuracy assessment of provided data for pH in water, pH in KCl and SOC are being tested. The data used for this study are 200,000 georeferenced samples collected from the territory of central Serbia from a layer of 0-30 cm depth. To create a functional GIS database containing 1,200,000 data of basic chemical soil properties, obtained from 200,000 sample locations, harmonization was previously followed. The main parameter according to which the data are harmonized is the coordinate system or projection used during sampling. Soil data are used to test the uncertainty of SoilGrids in a way that the point data from layers were subtracted to make a difference in data that will represent the SoilGrids error. The results showed that the deviations for the pH in water are from -2.1 to +2.2 pH units, i.e., in over 95% of samples from -1.0 to +1.1 pH units. Deviations for the pH in KCl are from -2.7 to +2.6 pH units, i.e., in over 95% of samples from -1.4 to +1.2 pH units. Testing the accuracy of SOC showed deviations from -50 to +25 g kg⁻¹, i.e., the most common deviations from 0 to +10 g kg⁻¹ of SOC. Observing that soil sampling and its chemical analysis at the national level are time-consuming, digital soil mapping is considered valuable for fast making decisions over a large-scale territory. To improve the prediction of the spatial distribution of soil properties, it is important to enhance state-of-the-art machine learning methods to map the spatial distribution of soil properties at a farm-level scale.

Keywords: SoilGrids, uncertainty, pH, SOC



TRACE ELEMENTS AND POLYCYCLIC AROMATIC HYDROCARBONS IN ANTARCTIC SOILS: VARIABILITY ACROSS LANDSCAPES

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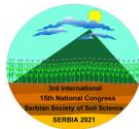
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Abstract

Despite of the fact that Antarctica is still considered as one of the most pristine areas on Earth, increasing rates of human presence (connected with scientific operations, functioning of the numerous scientific stations, tourism activities) creates conditions of high environmental risks in sensitive terrestrial environments of Antarctica. Effective realization of environmental protection measures is vital for saving unique ecosystems of the sixth continent as well as for appropriate compliance of the Antarctic Treaty's fundamental principles. These measures include environmental impact assessment and permanent monitoring of various components in natural ecosystems, such as soil. Soils play a significant role in processes of accumulation, mobilization, redistribution of chemical elements within landscapes, and ecosystems. The aim of this work was to analyze the levels of 17 polycyclic aromatic hydrocarbons and eight trace elements in soils different ice-free areas of Antarctica (Larsemann Hills, Haswell archipelago, Bunger Hills, King George and Ardley islands, South Shetland Islands). Soil of both anthropogenically-affected and near-natural landscapes have been investigated. Moreover, our work was aimed to determine the trends and reasons of anthropogenic pollution of Antarctic soils and characterization of accumulation levels of trace elements and PAHs. Results showed the predominance of light PAHs in all studied sites. The content of benzo(a)pyrene does not exceed the threshold concentration (adopted by different national environmental legislation systems). At the same time, the content of benzo(a)pyrene, which is a marker of anthropogenic contamination, is relatively low or equal to 0 in soils of reference landscapes. Cu and Zn were found as most abundant elements in all studied soils. The highest lead concentration content has been described in soil from Bellingshausen station. In general term, obtained Igeo values for trace elements in all samples were under or slightly above the 0 level, indicating low to moderate pollution of the studied soils. This study also contributes new data on trace element accumulation in soils strongly influenced by ornithogenic factor. Principal component analysis allowed to estimate the probable sources of specific trace metals and their relationship with soil variables. Ornithogenic factor has been also revealed as a driver for some trace element accumulation especially in breeding penguin colonies. High contents of organic matter in ornithogenic habitats could increase trace metal mobility, environmental risks for surrounding terrestrial environments should be considered.

Keywords: heavy metals, PAHs, soils, permafrost, ornithogenic effects



Soils for Future under Global Challenges

THE CONTENT OF Cd AND Pb IN UNDEVELOPED SOILS AND PLANT MATERIAL IN THE AREA OF NP (NATIONAL PARK) TARA

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Abstract

Ultramafic (serpenites) are a group of igneous or metamorphic rocks, which are characterized by high concentrations of Mg, Fe, Ni, Cr, and Co, along with low concentrations of Ca, P, and K, contain less than 45% silicon (SiO_2). Tara Mountain is natural good of western Serbia where areas under serpentinites occupy 28%. Researchers agree that the flora of serpentine areas is unique and botanically very important. The specificity of the flora and the development of vegetation on serpentinites are characterized by special mechanisms of plant species adaptation to increased concentrations of some heavy metals in the soil with low content of essential elements (nutrients). This paper examines the influence of serpentinite geological substrate on the occurrence of certain plant species in the initial stages of plant community development. The soil was mainly sampled in rock crevices in the early phases of soil development (*Lithosols*) where the influence and origin of the metal from the rock can be considered the most obvious. Content of cadmium (Cd) and lead (Pb) in geological substratum, soil and plants biomass are analysed in order to differentiate levels and extents of natural and anthropogenic pollution and also deposition data from the EMEP program (European Monitoring and Evaluation Programme). Results shows that the content of lead and cadmium in the soil and plant samples are higher than the content in the corresponding rock sample, this suggest that the origin of the increased Pb and Cd content might be from anthropogenic sources. Deposition (data from EMEP program) of Cd and Pb, witch were analysed for the period from 1990-2018, indicate significant cumulative effect. The values of cumulative deposition in research area have a value of 91,51 kg/km² lead, while the value of cadmium is 1665 g/km², which classifies NP Tara in above-average polluted area in R. Serbia.

Key words: serpentinite, heavy metals, parent material, soil, EMEP, deposition



Soils for Future under Global Challenges

ADAPTATION OF THE FARMING SYSTEM WITH COVER CROPS GROWING FOR INCREASING SOIL CARBON SEQUESTRATION

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Abstract

The aim of this research was to introduce a cover crop technology, by sowing white mustard (*Sinapis alba* L.) in organic field production. The research was conducted on the certified organic experimental plots at the Tamiš Institute (2.5 ha size), on Chernozem soil type from 2016 to 2020. During the study, oat was harvested (*Avena sativa* L.) and the soil was tilled with chisel plow (Mulch tillage) to allow for self-growth of oats sprouting. Direct sowing (No till) of white mustard was performed in such conditions. At the beginning of August, mustard seeds germinated thus establishing intercropped cover crop of oats and white mustard.

Accelerated growth of white mustard plants and established oat biomass in the mixed crop system contributed to the development of land cover. It was 80% in the end of August for all years of the research, and 100% in the phase of elongation of white mustard stem (BBCH 34). The green biomass of the cover crop was terminating by a roller crimper when 30% of white mustards were in bloom (BBCH 63) and the soil was tilled with chisel plow. The average total biomass was 9.8 t ha⁻¹ in the combined cover crop at the time of its destruction, oat biomass 1.5 ha⁻¹, and white mustard 8.3 ha⁻¹. The average C/N ratio of the white mustard biomass was 8.68:1, oats 13.78:1, and total biomass 9.48:1. The narrower C/N ratio of the total biomass obtained by this combination was favorable, because the nitrogen mineralized faster and became more available to the next crop. Average N content in biomass was 4.02%.

Soil respiration intensity was statistically significantly higher after the cover crop of white mustard and oats (1090.84 µg/g CO₂-C/week) compared to the control soil (447.53 µg/g CO₂-C/week). Carbon content of microbial biomass (MBC) was also statistically significantly higher (235.91/96.78 µg/g). There were no significant differences in microbial biomass (MBN) and nitrogen content. The obtained results indicate that the application of cover crops with white mustard and oats provides: 1. a continuous supply of organic matter in the form of green biomass, which is returned to the soil, 2. numerous and active microorganisms, due to replenishment of nutrients with fresh biomass and 3. The analysis of total microflora, ammonifiers, actinomycetes, *Azotobacter* sp. indicates a positive effect of white mustard as a cover crop on the number and diversity of microorganisms in the soil.

Introduction of a cover crop with white mustard in the crop sequence resulted that the crop rotation expanded and agrobiodiversity increased over time. The results indicate that proposed cropping technology contributes to the carbon sequestration and thus to the mitigation of consequences of climate change.

Keywords: Cover Crops, Intercropping, Soil Carbon Sequestration, White Mustard



DISSOLVED ORGANIC CARBON AS A CONTROLLING FACTOR OF NICKEL AVAILABILITY IN RECLAMATION OF BARREN SOIL

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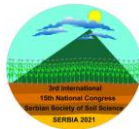
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Abstract

Lignite exploitation at Kostolac basin (Serbia) has generated over 4000 ha of surface deposited barren soil. We have investigated possibility to reclaim barren soil by growing arable crops, as the closest to an original function of a land, in a pot experiment under semi-controlled greenhouse conditions with maize as a test plant, in four replicates and with the following treatments: control, NPK (1000 kg ha⁻¹), farmyard manure (FM) (100 t ha⁻¹), coal dust (CD) (35 t ha⁻¹) and coal ash (CA) (35 t ha⁻¹). The barren soil was slightly alkaline (pH - 7.39), with low organic carbon content (0.228%). Pseudo-total contents (US EPA 3050B) of trace elements (TEs) (Ni, Cr, Pb, Zn, Cd, Cu) were below legislative thresholds, and their 0.005 M DTPA-extractable amounts were low. The experiment lasted 60 days, after which green biomass and roots were separated and their masses were measured. Contents of TEs were also determined in green biomass and roots (AAS method, after an acid digestion). Compared to the control, biomass was significantly higher in the treatments: NPK, FM and CD. However, high Ni contents were recorded in the roots in control (20.5 mg kg⁻¹) and in all treatments (from 24 mg kg⁻¹ in FM to 29.0 mg kg⁻¹ in NPK), which could not be predicted from the pseudo-total and DTPA-extractable Ni. This indicated that a reservoir of labile soil Ni was not properly predicted by the equilibrium-type DTPA extraction. Therefore, additional analyses of the barren soil after the experiment were performed: determination of dissolved organic carbon (DOC) and determination of labile Ni by the Diffusive Gradients in Thin Films (DGT) technique, a zero-sink approach. Nickel flux (μg Ni cm⁻¹ h⁻¹), calculated from the accumulated Ni mass in the DGT resin gel, was significantly correlated with root Ni ($r = 0.77$, $p < 0.05$), which confirmed that the solid phase was capable to resupply dissolved Ni in response to plant uptake. In addition, Ni root concentration was correlated with DOC ($r = 0.74$, $p < 0.05$), indicated that DOC might be an important factor controlling Ni plant-availability. Further, Specific UltraViolet Absorbance (SUVA), an indicator of DOC aromaticity, decreased in the order: CD > FM > NPK > CA > control and was correlated with root Ni ($r = 0.71$, $p < 0.05$). Thus, in our experiment, Ni availability might be equally controlled by DOC quantity and DOC quality, both resulting from organic amendments. Our results imply that addition of organic amendments in reclamation should be carefully combined with reclamation goal and detailed analyses of soil and plants, to avoid any adverse outcome either on the goal itself or broader in the environment. The results obtained should be evaluated with different arable crops and in field conditions.

Keywords: Barren soil, reclamation, nickel, DGT, DOC, SUVA



LEAD IN ALLUVIAL SOILS CONTAMINATED BY MINING ACTIVITY

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Abstract

Lead is one of the best known potentially toxic elements in the environment. It is relatively widespread in the earth's crust, but it also reaches the environment from human economic activities including mining. The aim of the study was to evaluate Štiavnica river alluvial soils contamination by lead coming from past mining activities. Soil samples from the depth of 0-0.1 m were collected from alluvium along the flow of Štiavnica river at 8 localities of which 6 were Fluvisols (2-7 study sites), 1 mine heap was environmental burden (1EZ, Technosol), and 1 reference site was located outside the alluvium (8S, Cambisol). We applied a Community Bureau of Reference sequential chemical extraction method followed by inductive coupled plasma optical emission spectroscopy analysis. Thus we observed the lead content in 4 different fractions (A – extractable, B – reducible, C and D – oxidizable and residual). The sum of elemental concentration of each fraction represents the near total concentration of lead in the sample. We also analysed basic soil chemical properties (pH, soil organic carbon – SOC, carbon ratio of humic and fulvic acids – $C_{HA/FA}$). We confirmed soil contamination by lead at all localities. The highest Pb content in A and B fractions among all sites was on the site 1 EZ (A fraction 185.70 mg.kg⁻¹, B fraction 1 979.85 mg.kg⁻¹). On the contrary, the lowest content of lead in A and B fractions was measured on the site 8S located outside the alluvium (A fraction 0.06 mg.kg⁻¹, B fraction 37.13 mg.kg⁻¹). Measured values of lead content in the A fraction at all localities situated at alluvium exceeded the Slovak limit value of lead (0.1 mg.kg⁻¹) in agricultural soils according to the Decree no. 59/2013. Of the total Pb content, the highest share was represented by B fraction (55.56%, ranging from 11.50 to 79.09%), followed by C and D (42.72%, ranging from 17.90 to 88.48%), and A (1.72%, ranging from 0.02 to 7.04%). A negative correlation was observed between B fraction and SOC. In opposite, a positive correlation was found between C and D fractions and SOC.

Keywords: soil contamination, lead fraction, alluvial soil

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CONTENT OF ORGANIC CARBON SOLUBLE IN HOT WATER (HWOC) IN WINTER COVER CROPS WITH SUBSEQUENT SOWING OF MAIZE GROWN ON CHERNOZEM

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Abstract

Preservation of soil quality is a continuous process in order to prevent negative effects of conventional cultivation. One of the main indicators of soil quality is reflected in its fertility. Due to insufficiently developed livestock production in the Republic of Serbia and insufficient amount of organic fertilizer (animal manure), there is a growing need for the introduction of alternative organic fertilizers that will be useful from both economic and environmental aspects. Therefore, the aspiration to maintain and preserve organic matter (OM) levels is considered as one of the preconditions for proper soil use and environmental protection. In the agro-ecological conditions of Vojvodina province of Serbia, there is an increasing need for the introduction of cover crops in order to improve soil fertility and increase the level of organic matter. On the other hand, there is no sufficient research on the impact of plowing cover crops on the content of labile organic matter (HWOC) done. The aim of the study was to determine the influence of different species of winter cover crops (CC) and maize on the content of OM as well as the dynamic of labile carbon. The research was carried out at the Rimski Šančevi experimental station of the Institute of Field and Vegetable Crops, Novi Sad. Type of soil was Chernozem. The winter CC consisted of the combined intercrops: winter pea (*Pisum sativum* ssp. *Arvense* L.) + triticale ((\times Triticosecale Wittm. ex A. Camus) (WPT) and single-species CC winter pea (WP) and control (C) (without CC). Plowing of CC and control plots was carried out at a depth of 27 cm in the last decades of May 2020, and the sowing of maize was done in early June. Nitrogen fertilization was performed in the form of top dressing with 50 kg N ha⁻¹. Soil was sampled in October at depth of: 0-20 cm, 20-40 cm. The analysis of variance determined a significant effect of cultivated crops (maize) in the subsequent sowing period on the change of the content of HWOC, as well as the interaction of cover crops and fertilization. The lowest value of HWOC in maize was measured on the control plots C N₀ (20-40 cm), and the highest value was found on the treatment WP N₅₀ (20-40 cm) (417.3 $\mu\text{g g}^{-1}$). The highest share of HWOC in the total OM content was measured on the variant WP N₅₀ (20-40 cm) (3.21%), while the lowest share was found on variant C N₀ (20-40 cm) (1.39%). Given that HWOC has seasonal dynamics, in the coming period it is necessary to conduct a series of research in terms of selecting appropriate cover crops as well as the time of soil sampling adjusted to the purpose of the research.

Keywords: winter cover crops, organic matter, HWOC, maize



Soils for Future under Global Challenges

ASSESSMENT OF SOIL EROSION USING THE EROSION POTENTIAL METHOD AND THE UNIVERSAL SOIL LOSS EQUATION IN THE GRAČANICA RIVER CATCHMENT (PRIJEPOLJE)

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Abstract

Soil erosion is one of the most common type of soil degradation, which causes significant danger to socio-economic development. Numerous empirical and physical soil erosion models have been developed to date. This paper's goal is to compare two very commonly applied methods worldwide – Erosion Potential Method (EPM) and Universal Soil Loss Equation (USLE). The investigation was performed within the area of the Gračanica river catchment. The river Gračanica, the tributary of the river Lim, is located in the southwestern part of the Republic of Serbia, in the municipality Prijepolje.

The calculation of the erosion coefficient (Z_{sr}) is a crucial step within the EMP method. It was estimated based on soil and vegetation cover, geological and pedological characteristics, relief, and visible degree of erosion processes. On the other side, the USLE method is calculated based on raindrop erosivity and erodibility that includes physical characteristics of soil and crop management. Both methods are implemented and calculated within the geographical information system (GIS) surrounding ArcMap (10.8.1) and GiSuS–M tool extension. The annual rate of soil erosion calculated by EPM is $536.32 \text{ m}^3 \cdot \text{km}^{-2} \cdot \text{year}^{-1}$, while according to the USLE method, soil loss is $6.35 \text{ t} \cdot \text{ha}^{-1} \cdot \text{year}^{-1}$.

For comparing these methods, measuring units are harmonized by multiplying the result of the EPM method by the weighted average of the soil density. The difference between these two methods shows 15 % more soil loss obtained by USLE than by the EPM method. The EPM method could be considered more accurate because it was developed in the Republic of Serbia in similar conditions as in this research area.

These results obtained within this research could present a base for further study, which could encompass setting the field experiment regarding erosion plots where the actual soil loss could be obtained.

Keywords: Soil erosion, USLE, Erosion Potential Method (EPM)



Soils for Future under Global Challenges

PLATINUM GROUP ELEMENTS AND RARE EARTH ELEMENTS IN URBAN PARK SOILS IN NOVI SAD, SERBIA

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Abstract

The aim of this research was to study the behaviour of “new” pollutants released from car catalytic converters in selected top and bottom soils in two urban parks in Novi Sad. The study of the anthropic pollution by a geochemical multi-element approach could be a useful tool overall in urban areas characterized by a high environmental complexity. Different catalyst honeycomb display typical Platinum Group Elements (PGE) and Rare Earth Elements (REE) associations and concentration levels not common in soil and, at the end, in the “natural” environment. Characteristic fingerprint that they displayed permit us to evidence the presence of particles derived from car catalysts. In Serbia, car catalyst introduction is relatively recent respect to other European Countries. Therefore, the preliminary data show that, among PGE, Pt and Pd concentration levels are 0.89 and 0.85 ng/g respectively, resulting still lower or very close to the typical geochemical background for these elements in natural soils and rocks. Then, the presented data can be utilized as useful reference values to assess their accumulation trend in Serbian urban soils. Concerning REE that are usually contained in high percentages in the catalyst honeycomb and released with PGE via car fume, the average concentrations of light REE (LREE) result lower in Novi Sad top soils (Σ LREE 112 mg/kg) than in Rome (Σ LREE 427 mg/kg), where catalyst were introduced in the early 90s and soil parent material is mainly derived from volcanic rocks. However, the REE distribution patterns result very similar in both cities as well as the REE concentration levels. These preliminary data evidence that the urban environment is continuously exposed to new pollutants in relation to changes in anthropic activity. Environmental safeguard require useful and innovative tools to check and study the fate of these potential pollutants overall in relation to potential negative effect on population.

Keywords: PGE, REE, park soils, pollution, Novi Sad, Serbia



Soils for Future under Global Challenges

CONTENT OF HEAVY METALS IN ARABLE PLOTS OF RASINA DISTRICT

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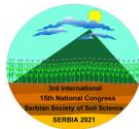
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Abstract

Rasina district is located in the central part of Serbia, on an area of 2,667 km² and includes the municipalities: Aleksandrovac, Brus, Varvarin, Kruševac, Trstenik and Čičevac. This district is recognizable as a very developed agricultural area, in which the following stand out: the valley of the West and Great Morava, the Ibar and Rasina valleys, that is, the Kruševac and Kraljevo valleys, then the famous Aleksandrovac parish or vineyards. The area of the municipality of Brus also covers the slopes of Kopaonik. In previous years, systematic fertility control including the basic agrochemical parameters of fertility was performed. The aim of the research was to improve the existing fertility control system through additional soil examinations (content of total and accessible forms of microelements and heavy metals) of certain cadastral parcels of registered agricultural holdings in Rasina district. Only on the basis of the complete examination good recommendations for the appropriate crops cultivation, as well as recommend adequate agrotechnical and ameliorative measures (calcification, application of organic fertilizers, foliar micronutrients) can be given. These measures primarily achieve the improvement of soil quality and maximum use of land potential, but also open the possibility of achieving high yields and product quality. The special significance of these results is reflected in the consideration of the possibilities of organic production on farms. One composite sample was taken from each of the 110 examined cadastral parcels from a depth of 0-30 cm. In the soil samples total and accessible forms of microelements and heavy metals were determined: arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), iron (Fe), manganese (Mn), and boron (B) were determined. Regarding the microelements and heavy metals content, a significant part of the examined cadastral parcels has regular values for unpolluted agricultural lands. The potentially harmful content of total nickel and chromium (30% and 20% of samples above 100 mg/kg, respectively), which is primarily of geochemical origin, was detected. There are higher concentrations of available Ni in 9% of samples, mostly on mountainous soils. In Vertisols (under vineyards) and in Alluvial Soils (under vegetable crops), where there is intensive protection with copper preparations, increased concentrations of total and available Cu (10% of samples had values above the maximum allowed) were observed, but below the limit when harmful effects on the plant occur. The Pb content above the maximum allowed value was found in only one sample. With the increase of the total Pb, the available ones also increase (in 4% of the samples), and the exact origin of the increased concentrations should be established by the next research. The low content of individual biogenic microelements was detected, primarily Zn (30% of samples) and B (50% of samples).

Keywords: soil fertility, microelements, heavy metals, Rasina district.



Soils for Future under Global Challenges

SOIL FERTILITY IN ORGANIC AND CONVENTIONAL PRODUCTION SYSTEMS

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Abstract

Agricultural production may lead to a decrease in soil fertility and it depends on the production system, climate, soil type, etc. The aim of the study was to determine the soil fertility of arable land in organic and conventional production systems and compare it with soil fertility under permanent pastures. The investigation was carried out on 6 localities in Vojvodina province with the same soil type (Chernozem). At each site, samples were taken from two plots under organic production (min. 7 and max. 13 years in the organic system), one plot under conventional production and one from pastures, from two layers of soil: 0 - 25 and 25 - 50 cm. A total of 48 collected soil samples were analyzed on physico-chemical and microbiological properties according to standard methods. The results show that production systems did not affect the content of plant-available phosphorus and potassium in both layers of the soil. The obtained results for the soil organic carbon (SOC) content in the soils (layer 0-25 cm) show that there were no differences between the organic and conventional system ($17.91 \pm 4.10 \text{ g kg}^{-1}$ soil and 18.70 ± 3.71 , respectively), while on the pasture SOC content was significantly higher (26.43 ± 7.89) in relation to the organic system. The estimated SOC reserve was in the same order as SOC content; organic ($60.59 \pm 6.85 \text{ t ha}^{-1}$) \leq conventional (64.50 ± 12.81) production < pasture soil (85.39 ± 23.45). The highest content of SOC on pasture is explained by the great potential of pastures to store organic matter. This also shows that better harmonization of plant production with livestock would contribute to increasing soil fertility in organic production. Regarding microbiological properties in the surface layer, there were no significant differences in the total number of bacteria between organic ($92.90 \times 10^6 \text{ g}^{-1} \pm 35.19$) and conventional ($79.53 \times 10^6 \pm 20.97$) production and on pasture ($67.41 \times 10^6 \pm 32.59$). However, a significantly higher number of azotobacters, as an important indicator of soil fertility and nitrogen balance, was determined in organic ($176.30 \times 10^1 \text{ g}^{-1} \pm 59.33$) in relation to conventional production ($106.40 \times 10^1 \pm 21.66$) and pasture ($67.89 \times 10^1 \pm 48.96$). There were no significant differences in the number of fungi between organic ($9.30 \times 10^4 \text{ g}^{-1} \pm 2.06$) and conventional ($8.37 \times 10^4 \pm 2.25$) production, but their number on pasture ($13.61 \times 10^4 \pm 2.09$) was significantly higher in relation to both systems. In the subsurface layer of the soil, there were no significant differences in the examined chemical properties and microbiological parameters between different production systems and pastures. The past period since the establishment of organic agriculture may be insufficient to improve all examined fertility parameters, as will be expected in the future.

Keywords: soil organic carbon, azotobacter, organic farming, intensive production, pasture



THE INFLUENCE OF SOIL ORGANIC MATTER ON ADSORPTION BEHAVIOUR OF TERBUTHYLAZINE IN BIOCHAR AMENDED SOILS

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Abstract

Organic matter (OM) plays an important role in the adsorption of pesticides in the soil. Biochar (BC), a carbon-rich and porous material produced by pyrolysis of biomass under oxygen-limited conditions, is added to the soil in order to enhance OM content and to improve soil capacity for water- and nutrient-holding capacity. Due to its adsorption capacity, BC decreases the mobility and bioavailability of organic pollutants. The aim of this study was to investigate the influence of OM in soil amended with BC on adsorption behaviour of terbuthylazine. Terbuthylazine was chosen as the most widely used triazine herbicide to protect maize crops. Soil 1, 2, and 3 used in the study contained 0.48%, 2.34%, and 4.12% OM, respectively. Commercially available compost-activated BC produced by pyrolysis of beechwood chips at 700°C and BC produced by pyrolysis of sunflower crop residues at 700°C were used. A batch adsorption experiments were conducted to investigate terbuthylazine adsorption in unamended soil and with the amendment of various doses of BC (0, 1, 5, and 10%). The concentration of herbicides in the aqueous phase at equilibrium, which is achieved after 72 h, was determined by GC-MS. The adsorption isotherms were well described with the Freundlich model (R^2 values ranged from 0.714 to 0.998). Values of Freundlich exponent n were less than 1 and they vary from 0.400 to 0.944. Single-point distribution coefficients (K_d) were calculated at selected equilibrium concentration ($c_e = 100 \mu\text{g dm}^{-3}$). K_d values for unamended Soil 1, 2, and 3 were 1.14, 14.13 and 12.65, respectively. In unamended Soil 1 the adsorption of terbuthylazine was lower in comparison to Soil 2 and Soil 3, which is in accordance with the fact that the OM content primarily affects the adsorption of pesticides in soil. K_d values in soil types amended with beechwood BC were in the range 3.72–30.92 in Soil 1, 10.56–50.74 in Soil 2, and 20.82–47.03 in Soil 3, while K_d values in soil types amended with sunflower crops residues BC ranged 14.80–2099.81 in Soil 1, 8.99–985.51 in Soil 2, and 19.98–946.28 in Soil 3. The results showed that the sorption capacity increased with increasing the doses of BC and was higher in soil types amended with sunflower crop residues BC. Both types of BC increased the sorption capacity of soil for terbuthylazine. Higher OM content in soil increases the sorption capacity of terbuthylazine in unamended soil, as well as in amended. However, with higher doses of both BC types, there is less difference between sorption capacities of soil types, which indicates that BC has an important role in adsorption in amended soils.

Keywords: soil, organic matter, biochar, terbuthylazine



SPATIAL PREDICTION OF THE SOIL ORGANIC MATTER IN SOILS OF OHRID VALLEY

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Abstract

Soil organic matter plays a central role in defining of soil functions and preventing its degradation. Processes ruling its turnover from one to the other pools are heavily influenced by a wide set of environmental factors or soil management practices.

For these reasons the overall contents of soil organic matter and its dynamics among different pools is very variable, spatially and temporally. Data collected during field survey are site specific and don't give an overall picture for the SOM spatial distribution and dynamics. There are numerous approaches in digital soil mapping enabling prediction of certain soil properties through integration of field soil data with other environmental co-variables.

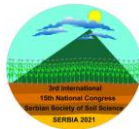
Investigated area was selected in a manner to outline the variability of factors influencing SOM content and distribution e.g. land use, relief forms, or management practices. Soil sampling locations were randomly distributed within a predefined mesh with a 1-sq.km spatial resolution and further stratified to outline different types of land use within each mash square. Such approach allows random coverage of the test area, what is of importance for further spatial modelling of the examined soil properties.

Soil samples were laboratory tested, showing a significant difference in SOM content, among particular land use types. Soil samples were collected from 93 locations in three depths on each 20 cm., covering a total area of 10 thousand ha of arable, forestland and land under natural vegetation. The content of soil organic matter in the top layer (0-20 cm.) of forestland, out of 21 examined locations is in average 6.81%, while on a 22 examined locations under grassland, the average content is 4.07%. Arable land, which is under continuous human impact, has the lowest contents of SOM of 2.5% under field crops and 2,61% in perennials.

A set of additional environmental data were collected for the tested region, needed as an input data, like: soil map, land use map, geology map, digital terrain model and its derivatives, satellite images and climate data. The collected data were converted into a grid datasets and further harmonized and overlapped. Additional indices, highly correlated with the overall plant productivity and production of organic material, such as: NDVI, SAVI, BI etc., were developed as well.

Multilinear regression models were used for spatial prediction of the soil organic carbon. The results of the modeling process gave a better spatial overview and identified the most vulnerable areas for SOM depletion. As expected, the highest contents are under forestland, and pastures, while the areas with lowest SOM contents are in the bottom part of the valley which is under intensive agricultural production. Uncertainty analysis showed a highest uncertainty on a sloppy terrains with mixed land use, which abruptly changes over short distances.

Keywords: soil organic matter, digital soil mapping, modelling, land use



MERCURY TOTAL CONTENT ACROSS SOIL TYPES IN AGRICULTURAL LAND OF VOJVODINA PROVINCE (SERBIA)

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Abstract

Mercury (Hg) has been listed by international organizations as a high-priority pollutant due to its mobility and persistence in the environment as well as its high toxicity to biota. Mercury occurs in soil in several ionic forms susceptible to transformations. These processes, among other factors, are conditioned by physical and chemical properties of soil, which in turn depend on the soil type. A grid superimposed on the Pedological map of Vojvodina (1:50.000) by means of GIS tool (GIS ArcView 10) divided the land into 4×4 km units, each representing an area of 16 km². The total of 1.369 representative soil samples were taken from agricultural land (0-30 cm depth). The samples were analysed using Direct Mercury Analyzer DMA 80 Milestone. QC was carried out with BCR reference materials 143R. According to the uniform grid, the number of collected samples coincides with the spatial distribution of soil types in Vojvodina: Chernozem CH 856 samples, Gleysol GL 213, Fluvisol FL 119, Solonetz SN 49, Cambisol CM 30, Solonchak SC 27, Vertisol VR 23, Arenosol AR 14, Regosol RG 13, Stagnosol ST 13 and Leptosol LP 12 samples. Parameters of descriptive statistics and the Fisher LSD test ($p \leq 0.05$) were conducted using software Statistica, version 13. The average (median) value \pm SD of total Hg (THg) in the observed soil types ranged from 0.018 (0.016) \pm 0.008 ppm in Arenosol to 0.149 (0.085) \pm 0.085 ppm in Fluvisol, while it was 0.057 (0.047) \pm 0.059 ppm in the most abundant soil type, Chernozem. The obtained results complied with GEMAS project, where the median value for Central Europe amounted to 0.05 ppm. Based on the median value of THg content, the observed soil types had THg content in the following order: AR-RG-SC-CH-VR-GL-LP-CM-SN-ST-FL from the lowest to the highest, respectively. According to the established statistically significant differences, AR and FL differed in their respective THg contents as well as compared to all the other observed soil types. In the determination of the difference between higher systematic soil units, hydromorphic soils noticeably differed from automorphic and halomorphic soils while, among classes, fluvial soils exhibited different values than all the other observed units. The increased THg concentration in Fluvisol soil type could be the result of industrial and communal activities.

Keywords: Mercury, Hg, Soil, Soil type, Fluvisol



Soils for Future under Global Challenges

SPARSELY CROSSLINKED BIODEGRADABLE HYDROGEL AS A MULTIFUNCTIONAL SOIL AMENDMENT

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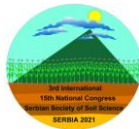
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Abstract

While using polyelectrolytes as soil ameliorants, there are two main directions. The first is the use of linear polymers: when treating the surface of soils with their solutions, a protective polymer-soil cover is formed, which prevents the spread of dust by the wind, erosion by water flows and mechanical destruction of soils in general. However, linear polymers do not directly affect the water-holding capacity of soils. This is where the second direction takes place: the use of hydrophilic covalently crosslinked polymers with network structure, which, when swollen in an aqueous medium, form hydrogels capable of long-term moisture retention, and when mixed with soil, significantly increase soil moisture retention, prevent water evaporation. However, such ameliorants, in turn, do not have the ability to form protective polymer-soil compositions, and do not contribute to the improvement of mechanical stability of soils. It should be noted that there are almost no descriptions of complex acting polymeric soil conditioners that cope with both described tasks at once. This paper presents the results of the use of super-readily cross-linked hydrogel as a soil ameliorant with a complex action that has the ability to biodegradation. For this purpose, a crosslinked copolymer based on acrylamide, potassium acrylate and starch (biodegradable component) was obtained, hereinafter - AM-AK-Starch #. N, N-methylene-bis-acrylamide was used as a crosslinking agent; its mass content in the monomer mixture was 0.036 wt%. After the synthesis of the polymer in the block, it was crushed and divided into two fractions: <0.25 mm and 0.25-0.5 mm. For comparison, we also used a commercial medium crosslinked hydrogel (SNF, France), a copolymer of acrylamide and sodium acrylate, which was ground and fractionated in a similar way. The maximum degree of swelling of AM-AK-Starch # is 2-3 times higher than that of commercial one, which is explained by a lower degree of crosslinking and a higher degree of ionization. However, in experiments with quartz sand and sandy loam soil, it was found that the sparsely cross-linked hydrogel is unable to resist the pressure of the outer layers of the soil. Therefore, its degree of swelling drops sharply compared to the average cross-linked commercial one. Nevertheless, AM-AK-Starch # showed decent indicators for improving the water-holding properties of soil/sand in the range of mass contents of 0.5-1 wt.%. In addition, it was further shown that the commercial hydrogel is not capable of forming a single polymer-soil composition resistant to mechanical stress, while AM-AK-Starch # formed a single stable polymer-soil crust. Thus, soil composites based on commercial sample were unable to withstand water and air flows, almost completely collapsing, and crusts based on AM-AK-Starch # retained their integrity even when exposed to wind up to 30 m/s.

Keywords: soil erosion, water retention, hydrogels, soil amendments



Soils for Future under Global Challenges

SURVEY OF TERRAIN DEPRESSION USING UNMANNED AERIAL VEHICLE

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Abstract

In recent years, there has been an increasing trend in the use of unmanned aerial vehicles (UAVs) in agricultural research. With the help of images made by a camera mounted on an unmanned aerial vehicle, phenomena on the plot, which are often not visible to the human eye, can be mapped in detail, thanks to images taken in the invisible part of the light wave spectrum. However, not only the technique of ordinary aerial photography is applied, but in a special procedure of shooting and processing images, called photogrammetry, one can get both a three-dimensional model of the captured terrain and an orthophoto mosaic, which corresponds to the orthogonal view of the terrain. In this research, a photogrammetric survey of one natural depression on an agricultural plot using different photogrammetric survey parameters (flight altitude, flight plan, different cameras, different number of landmarks) was performed to determine the accuracy of the position and height of the points that make up the DTM of the study area. The position and height of the characteristic DTM points were compared with the values determined by GNSS or leveling. Due to much less error compared to other measurement methods, the height differences obtained by leveling can be considered as accurate values. During the survey of the plot, using a camera built to the Phantom P4 V2 drone for a flight altitudes of 50 m, 80 m and 120 m, the corresponding ground sample distances (GSD) of 0.016 m, 0.026 and 0.038 were obtained, respectively. After reading the DTM values for 39 landmarks, the standard deviation of height difference from leveling method was 0.019 m (50 m flight altitude), 0.037 m (80 m) and 0.043 m (120 m). For the purpose of photogrammetric processing, 5 GCPs were used, which position was determined by the GNSS method. Regarding the number of GCPs required for photogrammetric processing, at an altitude of 80 m, the processing was performed using from none to 21 GCPs. A minimum of 3 GCPs was found to be required. The standard deviation of the DTM height difference from leveling method was 0.041 m (3 GCP used), 0.025 m (6 GCP used) 0.019 m (15 GCP) and 0.016 m (21 GCP), respectively. Considering the standard geodetic methods of terrain surveying, the survey of depression using UAV from a flight altitude of about 100 m above the ground using 5 or 6 GCP will obtain a DTM approximately the same accuracy but in much more detail.

Keywords: Unmanned Aerial Vehicle, photogrammetry, DTM, terrain depression



CARBON SATURATION POTENTIAL IN LONG-TERM WHEAT CROPPING SYSTEMS ON CHERNOZEM

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Abstract

Sequestration of atmospheric carbon (C) in soils is considered an important tool in CO₂ mitigation, therefore various management options for increasing soil organic carbon (SOC) have been discussed. Agricultural soils are characterized with high C sequestration potential, but promising management strategies are slowly accepted. Several studies showed that there is an upper limit of SOC storage that represents C saturation at a specific level where soil losing its ability to stabilize soil organic matter against microbial mineralization. Conversely, C saturation indicated historical loss of SOC. To evaluate C saturation data was acquired from the long-term experiment on a Haplic Chernozem at the Rimski Šančevi experimental station of the Institute of Field and Vegetable crops. Soil samples were collected from the winter wheat and adjacent land (control) for 0-20 cm and 20-40 cm depth under the following treatments: 4-year rotation with manure 40 t ha⁻¹ (BØ); 4-year rotation, manure 40 t ha⁻¹+100 kg N ha⁻¹ (B2); 4-year rotation 200 kg N ha⁻¹ without crop residues (A4); 4-year rotation 200 kg N ha⁻¹ +crop residues (C4); wheat monoculture + 100 kg N ha⁻¹ (MO); 2-year rotation + 100 kg N ha⁻¹ (D2); 3-year rotation + 100 kg N ha⁻¹ (D3); unfertilized 2-year (N2); 3-year rotation (N3) and native vegetation (NV). The potential C saturation (C_{satpot}) of particles <20 µm was calculated using the equation of Hassink (1997). To calculate the C saturation deficit (C_{satdef}) measured C concentrations of the fine fraction were subtracted from the potential C saturation. The total amount of the C sequestration potential was calculated using the Weismeyer et al. (2014) equation C_{seq}=C_{satdef} x BD x depth x 10⁻². In the topsoil C_{satdef} was lower at the control and higher at unfertilized 3-year rotation. C sequestration in 0-20 cm soil depth was 2.78 kg m⁻² being higher at D3 and lower at B2. In the 20-40 cm soil depth average C_{seq} was higher compared to topsoil (3.02 kg m⁻²) indicating the higher potential for SOC storage and preservation. The ratio of bulk SOC in C_{satpot} averages at 61.48 % and 57.04% for the 0-20 cm and 20-40 cm, respectively. This showed the capacity of, approximately, 40% increase in SOC of Chernozem with using carbon smart agriculture systems in the future. Correspondingly, improvement in SOC would be more efficient in soil with lower SOC content. The obtained result could have implications in adopting "4 per Mille" (4p1000) strategy that suggested that an increase of 0.4% yr⁻¹ in SOC stock.

Keywords: C saturation, C sequestration, climate change mitigation, Chernozem



LAND COVER/LAND USE IN SERVICE OF AGRICULTURAL LAND PROTECTION, USE AND RESTRUCTURING

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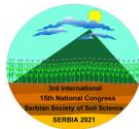
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Abstract

According to the Law on Agricultural Land of the Republic of Srpska, municipalities and cities are obliged to prepare a planning document “Groundwork for Agricultural Land Protection, Use and Restructuring (The groundwork)”. The Groundwork of municipalities is made by GIS analysis and processing of existing relevant data on land resources and climate (terrain model, pedology, land cover, land use, climate data, etc.). GIS modeling of existing data was used to create new relevant data (bonity, agro-ecological zoning, suitability of cultivation, etc.) which are used in the decision-making process. The GIS layers are made in ArcGIS software, in the scale of 1:100000, 50000, 25000, except the land cover and land use layer (LC/LU) which is made in the scale of 1:5000. This paper presents a semi-automatic and manual method of digitization (vectorization) of the LC/LU classes on the example of making the Groundwork of Laktaši municipalities. Orthophoto images from 2012 were used to delineate the LC/LU areas. The Google Earth satellite images from 2017 and 2018 were used to determine the changes in the LC/LU from 2012 compared to 2018. The obtained LC/LU result is presented in the form of a polygon (shape file). The Land Cover Classification System (LCCS-FAO), adapted to the conditions of BIH, was used for the delineation of the polygon. According to LC/LU data, agricultural areas occupy 49.5% of the municipality, which is a decrease of 15.8% or 6137 ha compared to the data from the cadaster. Of this area, 418.4 ha was converted into unproductive land (built up areas), and most of the changes were identified with the increase of areas under woody vegetation, i.e. in overgrowing of uncultivated areas (17.7% or 5719 ha). Regarding the degraded areas, exploitation fields of gravel were dominating (217 ha or 0.6% of the total area of the Municipality). In addition to the gravel exploitation from the Vrbas River Basin, the gravel was exploited from the agricultural areas as well. By overlapping the bonity map with the built-up areas, it can be concluded that 264 ha of land of the first bonity class, 61 ha of the second and 397 ha of agricultural land of the third bonity class were permanently lost, which totals in 722 ha of the most productive land. A comprehensive analysis found that there was a significant increase of non-agricultural land area, and significant reduction of cultivated land in relation to arable land.

Keywords: Land cover/Land use, GIS modeling, land degradation, land conversion



Soils for Future under Global Challenges

THE DYNAMICS OF CHEMICAL PROPERTIES IN THE MINE TECHNOSOLS AFTER SIX YEARS OF RECLAMATION

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Abstract

The open pit mining results in disturbance of a very large area landscape. The research of agro-technical and biological phases of soil reclamation by seeding and growing different agricultural crops was conducted on technogenic soil in Stanari coal basin. The aim of this survey refers to implementation of reclamation of technogenic soil in Deposol–plant–Rekultisol system on plateau at internal disposal area for overburden from Raskovac open pit in "EFT – Rudnik and Termoelektrana Stanari" (Republic of Srpska, Bosnia and Herzegovina). Several forms of reclamation and techniques were applied (agrotechnical and biological reclamation, fertilization, seeding, mowing in a mulch system), as well as the studied changes and development of technogenic soil. The survey task refers to examination of the dynamics of main chemical properties in the technogenic soil through six-years period reclamation (2011–2016). The analyzed chemical properties in technogenic soil are as follows: organic matter content, humus content, N, P₂O₅, K₂O. Biological reclamation is carried out by establishing the vegetation in two directions: seeding perennial grassland, and growing of annual arable crops. The research was conducted in a direct type of reclamation of the sandy-loamy Deposol adverse physical and chemical properties. Potential toxic elements in the Deposol are below the allowable limits. Application of agromeliorative measures and techno-pedogenesis process in six-years has resulted in forming Rekultisol with improved chemical properties. The initial process of humification and mineralization are started in Rekultisol formed. The content of organic matter in surface layer of Rekultisol (at 20 cm) has the average increase by 2.85 times. The average value of organic matter content at the beginning of the research was 2.3% and at the end 6.55%. From the initial zero value of humus content, in the end of the survey amounted to 0.8%, content of N to 0.075%, and content of P₂O₅ to 1.9%. The content of K₂O has the average increase by 7.6 times. Technological fertility of Rekultisol represents the result of implemented measures of reclamation and agrotechnic that, depending of time distance, with the leading climatic impact, affect the technogenic parent substrate.

Keywords: Deposol, Rekultisol, seeding grasland, arable crops



Soils for Future under Global Challenges

BIOACCUMULATION OF CHROMIUM IN *MEDICAGO SATIVA* L. AND *TRIFOLIUM PRATENSE* L. ON DIFFERENT SOIL TYPES OF SERBIA

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Abstract

Soil contamination with heavy metals threatens the health, production and biodiversity of ecosystems. Higher concentrations of Cr in soil can have a very toxic effect on plants and can result in bioaccumulation that can cause human health impacts via the food chain. The aim of this study was to determine bioaccumulation of Cr in *Medicago sativa* L. and *Trifolium pratense* L. on different soil type of Serbia, and to estimate their contamination level and the suitability for phytoremediation and phytomanagement. The study was carried out on six different soil types: chernozem, vertisol, eutric cambisol, fluvisol, humofluvisol, and humogley. Significant differences between the content of Cr were determined in different soil types. The highest pseudo-total content of Cr in soil was observed in fluvisol and vertisol, above the threshold value, but did not exceed remediation value. The lowest content was in chernozem. Bioaccumulation was highly correlated with the soil pseudo-total Cr content. The average Cr content in plant material differed between different types of soil. Although alfalfa has the higher capacity for Cr accumulation, Cr content did not differ between alfalfa and red clover. The concentration of Cr in above-ground biomass of the plants was below critical and toxic levels on all soil types. The low Cr content in the aboveground biomass suggests that alfalfa and red clover can be considered an excluder species, valid as a candidate for Cr-contaminated soils' phytomanagement. Further control of Cr content in contaminated localities is needed to prevent their entry into the food chain.

Keywords: alfalfa, red clover, heavy metals, soil.



ECONOMIC MODEL OF RAISING SOUR CHERRY PLANTATIONS ON TECHNICALLY RECULTIVATED LAND AREA

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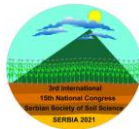
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Abstract

The Experiences so far in the world and in the Republic of Serbia show that it is possible to create new agricultural, forest, recreational, landscape, and other systems through reclamation. Biological measures include the application of agricultural and forest reclamation, which contribute to the stability and maintenance of reclaimed areas, but are much more important from the aspect of spatial revitalization and the establishment of natural biocenoses. The need for land reclamation in Serbia is especially pronounced in the surface exploitation of coal, primarily in the Kolubara and Kostolac coal lignite basin. Based on data from practice and technical-technological norms, in this paper an economic model of investing in raising and exploiting cherry orchards on a technically recultivated land area at the location of a former coal mine in the western part of Serbia was compiled. The aim of the research is to determine the amounts and reach a solution to some questions that are more important for the investor, such as: What is the upper limit of investing financial resources? With what degree of interest and within what period can the invested capital in the investment be returned, etc.? By determining the indicators of return value, net present value, internal interest rate and others, the economic justification of the investment was assessed. Input-output parameters and indicators of economic justification were made for one hectare of sour cherry orchard area, with a cultivation period of three years and an exploitation period of 15 years. Investments in the establishment and cultivation of sour cherry orchards are set at 7,800 €/ha. The average annual net profit from sour cherry production is 2,800 €/ha. With an interest rate of 8%, the net present value of sour cherry orchards is 16,168 €/ha, and the yield value is 23,968 €/ha. The accumulation rate is 36%. The capital invested in raising sour cherry orchards can be returned in the third year, which is a much shorter period compared to the period of exploitation of orchards. By applying appropriate criteria for making an assessment, based on established economic indicators, such a project is economically justified. Opportunities, weaknesses, threats and potential risks to the economic viability of the reclaimed area were considered. From the aspect of the wider environment and general interests, an analysis of the relationship between benefits and costs, as well as potential qualitative environmental, social and economic external effects.

Keywords: Reclamation, investment, sour cherries, sustainability



POLLUTION INDICES OF TRACE ELEMENTS IN SOILS OF PČINJA AND JABLANICA DISTRICTS

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Abstract

Soil samples collected from two districts of southern Serbia, Pčinja and Jablanica, were analyzed in order to determine the content of eleven heavy metals and metalloids (As, B, Cd, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Zn). The concentration of the elements was measured by atomic absorption spectrometry in 152 samples collected from agricultural land. The main goal was to assess the environmental and health risk of eleven heavy metals and metalloids tested in the soil. To determine the degree of soil contamination, measured concentrations were compared with limits and remediation values given in the Serbian Rulebook. It was determined that the average content of tested elements in mg/kg was: As (12.76), B (113.73), Cd (1.10), Cr (58.01), Cu (29.62), Hg (0.33), Mn (1067.89), Mo (0.21), Ni (34.85), Pb (233.38), Zn (64.49). The average content of all examined trace elements in soil did not exceed the remediation values. However, the average content of Cd, Hg, Pb exceeded the limit values. Five pollution indices were used to assess environmental risk: enrichment factor (EF), geoaccumulation index (I_{geo}), contamination factor (CF), pollution load index (PLI), and potential environmental risk index (RI). Based on EF and I_{geo}, it was concluded that the biggest problem was As, Hg and Pb. More than half of the samples are moderately contaminated with Pb, over 30% of samples are heavily contaminated with Hg, while some samples were highly polluted with As. Contamination factor, as well as PLI and RI, showed moderate contamination of the soil with Hg and Cd. The health risk assessment was estimated by hazard index (HI) and the carcinogenic risk index (CR), which determine the non-carcinogenic and carcinogenic effects that heavy metals can cause in the human body, through ingestion, inhalation and dermal contact with contaminated soil. This study showed that there was no non-carcinogenic risk as adults-hazard index (HI) calculated for each sample was less than one. On the other hand, there was a higher risk for children's health since over 85% of soil samples had HI values greater than one. Combine carcinogenic risk of all elements was estimated with lifetime carcinogenic risk (LCR). There is no risk of developing cancer in both groups because more than 90% of the samples had acceptable carcinogenic risk values between $1,0 \cdot 10^{-6}$ i $1,0 \cdot 10^{-4}$, while a small number had concern LCR values greater than $1,0 \cdot 10^{-4}$.

Keywords: heavy metals, soil pollution, ecological risk, health risk, south Serbia



NATURALLY OCCURRING RADIONUCLIDES AND BASIC CHARACTERISTICS OF SOIL AND ASH SAMPLES NEARBY COAL-FIRED POWER PLANTS

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Abstract

Deposition of (fly and bottom) ash generated after coal combustion in the coal fired power plants (CFPP) in Serbia is carried out in active and passive lagoons. Ash waste mixed with water is directly transported to the lagoon currently active and the other one is passive in the stage of temporary inactivity for technical consolidation of ash and drainage and subjected to revegetation process using grass-legume mixtures in order to create plant cover. In order to obtain similarity, samples studied in this work were all taken from the area covered with grass which included: (1) soil close to CFPP (<2 km), (2) soil further from CFPP (>2 km) and (3) ash from the flat area of associated passive lagoon. Investigated sites were four power plants: TE “Kolubara” (TEK), TE “Morava” (TEM), TE “Nikola Tesla” A (Tent A) and B (Tent B). In order to analyze environmental implications of ash deposition in the surrounding area, basic characteristics such as texture, particle size distribution, pH value, organic matter and carbonate content were determined in the soil and ash samples. Simultaneously, ²³⁸U, ²²⁶Ra, ²¹⁰Pb and ²³²Th activity concentrations were measured as it is known that after elimination of the organic component of the coal in the process of combustion naturally occurring radionuclides activity concentrations in the coal ash could be enhanced up to 10 times. Analyses of differences between soil and ash samples collected in this study showed that for one group of soil some changes of physical and chemical characteristics occurred compared to the rest of soils. These changes were found to be related to the soil texture, percentages of clay size particles and ²³²Th/²²⁶Ra activity concentration ratios.

Keywords: soil, ash, CFPP, naturally occurring radionuclides



LAND USE EFFECTS ON SOIL PORE-SIZE DISTRIBUTION AND SOIL WATER RETENTION

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Abstract

Soil pore characteristics can have great impact on plant growth and environment. A study was conducted to evaluate the effects of different land use on porosity, pore size distribution (PSD) and soil water retention (SWR) of Fluvisol Phaeozem in the Kolubara River valley, Serbia. The land use treatments included: natural forest, native meadow, and arable land managed in the same way for more than 100 years. Disturbed and intact soil samples were collected from three soil profiles at each of the three different land use types from depths of 0–15, 15–30 and 30–45 cm. The capillary rise equation was used to estimate effective pore sizes from water retention measurements. Pressure cells are used to measure water retention in the water potential range from –33 to –1500 kPa. The bulk density (BD) was significantly ($P < 0.05$) larger for meadow (1.48–1.49 g cm⁻³) and arable land (1.28–1.42 g cm⁻³) than forest (0.99–1.29 g cm⁻³) at the top 30 cm of soil. There was no significant difference in BD between meadow and arable land in the subsurface soil layer (15–30 cm). Depending upon the increases in BD and disruption of pores by mowing and tillage management, total porosity decreased accordingly in meadow and arable land. Land use had significant effect on PSD. Volume of macropores (> 30 μm) were significantly higher for forest (10.93–16.19%) than meadow (4.77–5.74%) and arable (4.83–7.81%) land for 0–30 cm soil layer. Among the different land use types, forest and arable land had significantly higher mesopores (30–3 μm) volume compared with meadow. Mowing and tillage management significantly decreased volume of micropores < 3 μm diameter size at the 0–30 cm soil depth. The plant available water (PAW) was the lowest in meadow at depth of 0–15 cm. Soil under natural forest and arable land did not show significant difference in PAW at depth of 0–30 cm. In conclusion, our results showed that total porosity, PSD, and moisture retention significantly changed because of the different management systems in the top 30 cm of soil, which can potentially influence crop yields and ecosystem function.

Keywords: Fluvisol Phaeozems, forest, meadow, arable land, bulk density, total porosity



Soils for Future under Global Challenges

ANTHROPOGENIC INFLUENCE ON HUMUS CONTENT IN DIFFERENT SOIL TYPES

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Abstract

The region of Vojvodina (coordinates of the geographical center - 45°24'05" N, 20°04'53" E) administratively belongs to the Republic of Serbia (northern part), while its geomorphological position is in the southern part of Central-European Pannonian Plain. Besides other pedogenic factors (parent material – mostly loess, relief – mostly flat, climate – semiarid, with mean annual temperature of 11°C and the period i.e. duration of pedogenesis), the formation of soils in this region was affected mostly by organisms and human. Natural environment affected the formation of soils through natural herbaceous vegetation represented by steppe grassland (*Festuca sulcata*, *Agropyron* sp., *Andropogon ishaemum*, *Stipa pennata* etc.), which leaves a large amount of well-distributed alkaline organic matter in soils, causing the development of soil types well-supplied with organic matter (with the natural humus content above 5%) at 75% of Vojvodina surface. The main soil-forming process was accumulation of humus. The main formed soil types are Chernozems (FAO soil type Chernozems) and Humogleys - Hydromorphic black soil (FAO soil types Vertisols and Gleysols). The effect of man as a pedogenic factor was visible in the last 100 years. Deep tillage was performed during the period of intensive agriculture, along with soil aeration and intense mineralization of soil organic matter. Mineral fertilizers were preferred over organic fertilizers, which disturbed the natural cycling of soil organic matter, resulting in significant decrease of its content. Many systemic soil analyses have been carried out since 1950s in order to determine the dynamics of soil organic matter content in the region of Vojvodina. During 1950s and 1960s, analyses were conducted for the purpose of creating a pedological map at the 1:50.000 scale. The network of soil samples covering the territory 4x4 km in size (Soil grid was 4 times 4 km) - over 1300 samples, was established in early 1990s, while sampling and analyses were repeated in early 2010s. Research results revealed the decrease in organic matter content by about 0.38% until 1990s, and henceforth by an additional 0.5%, depending on different soil types. The significance of organic matter content to soil fertility created the need for increased future application of organic fertilizers, as well as more rational soil tillage, higher amounts of applied green manure, etc.

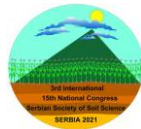
Keywords: pedogenic factors, soil types, organic matter

Acknowledgments: Part of this study was conducted as part of the Project No. TR 31072: "Status, trends and possibilities to increase the fertility of agricultural land in the Vojvodina Province", which is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.



Soils for Future under Global Challenges

SECTION 4: SOIL AND WATER FUTURE SOCIO-ECONOMIC PATHWAYS



NEW APPROACH TO IMPROVE WATER QUALITY IN THE DANUBE REGION BASED ON THE ECOSYSTEM SERVICES IN FLOODPLAINS: IDES PROJECT

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Antonić

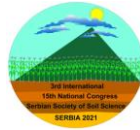
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Abstract

From its source to its mouth in the Black Sea, the Danube River covers a distance of more than 2,800 kilometers. Flowing through ten countries its water comes from 20 different countries. More than 80 million people live in the catchment area of the river, and - just like flora and fauna - all are dependent on a good water quality. The nutrients flow the Danube water does not stop at national borders and there is a challenge to establish strategies for comprehensive water quality management at the international level. Additionally, the floodplains along the Danube play a key role in quality management s, as they are able to retain nutrients. Two aspects in this regard are of interest. The first is: how floodplain areas along the Danube contribute to improving water quality, and the second: how can diverse interests be taken into account in water quality management across national borders? Answering these questions is the main concern of a multinational project IDES under the leadership of the Catholic University of Eichstaett-Ingolstadt, Germany. The project consortium involves over 20 institutions from ten countries along the Danube (Germany, Austria, Romania, Hungary, Slovenia, Slovakia, Bulgaria, Serbia, Croatia and Moldavia). The project title 'Improving water quality in the Danube river and its tributaries by integrative floodplain management based on Ecosystem Services (IDES)' implies that the project should enable partners to jointly develop and implement a transnational integrative ecosystem service approach, improve water quality management, and generate win-win-situations for multifunctional floodplains instead of trade-offs in a multi-actor, multi-sector framework. During the two-and-a-half-year implementation timeline, project activities will be focused on: (1) analysis of the actual situation of water quality and its pressures, assessment and comprehensive evaluation of ecosystem services in the whole Danube region by geographical explicit models, detail GIS analyses and literature review; (2) harmonization of different approaches and joint development of the framework of an ecosystem service evaluation tool (IDES tool) on basis of different enquiries; (3) stakeholder workshops in five pilot areas in Austria, Slovenia, Hungary, Serbia and Romania where innovative water quality management concepts will be elaborated and assessed by the newly developed IDES tool; and 4) joint work on developing a transnational strategy that will provide the operational pathway to integrate the ecosystem service approach in future water quality planning processes. The IDES project is co-funded by the European Union (ERDF, IPA).

Keywords: water quality management, ecosystem services, floodplain, IDES



Soils for Future under Global Challenges

PROMOTING THE APPLICATION OF SMART TECHNOLOGIES IN AGRICULTURAL WATER MANAGEMENT IN BOSNIA AND HERZEGOVINA

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Abstract

The adoption of smart agricultural water management in Bosnia and Herzegovina (BiH) is becoming a priority due to climate change, which increases weather uncertainty, and the necessity to promote a more efficient and sustainable use of resources in agriculture. In this context, a new project - SMARTWATER - is funded by the European Commission (EC) under the Twinning HORIZON 2020 program. The project is coordinated by the University of Banja Luka (BiH) with the aim to promote the application of smart technologies (cloud-based and remote sensing) in the agricultural water management in BiH. The project partners are University of Sarajevo (BiH), Mediterranean Agronomic Institute of Bari (Italy), Consejo Superior de Investigaciones Científicas (Spain), Instituto Superior de Agronomia (Portugal), and SYSMAN PROGETTI & SERVIZI SRL (Italy). The joint research activities started in 2021 at the experimental sites of Aleksandrovac (University of Banja Luka) and Butmir (University of Sarajevo) both characterized by typical continental climate. The objective is to investigate the applicability of smart technologies to improve maize crop productivity under different water and nitrogen treatments. Moreover, the results will indicate the best management practices by means of the most efficient use of resources in the context of water-energy-food nexus and reduction of negative environmental impact.

Keywords: HORIZON 2020, Agricultural Water Management, Smart Technologies, On ground monitoring, Remote Sensing monitoring



Soils for Future under Global Challenges

THE SPANISH SOCIETY OF SOIL SCIENCE: ACTIVITIES AND PROJECTS

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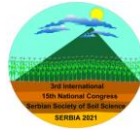
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Abstract

Founded in 1947 by the Spanish National Research Council (CSIC), the Spanish Society of Soil Science (Sociedad Española de la Ciencia del Suelo, SECS) promotes the cohesion and collaboration between soil science experts. Our main objectives are to promote the study, knowledge, research and protection of the soil; to disseminate the importance of the soil for our society thanks to the different ecosystem services such as the production of food and raw materials. The SECS also focus on its role in climate regulation, water quality control, food quality and human health. One of its concerns is to acknowledge the soil management and use, both from the production and environmental point of view, in order to optimize its capabilities. To achieve these objectives, the SECS develops a series of activities and projects. In this session some recent examples will be shown, such as: the biannual publication of the NEWS-SECS bulletin to disseminate the main activities of the SECS members; the Spanish Journal of Soil Science (SJSS), the official scientific journal of the SECS, from now on published by Frontiers; the creation of a soil science documentary centre in the University of Santiago de Compostela; the organization of congresses, conferences, courses, exhibitions, the edition of an annual calendar; the comic “Living in the soil” in different languages, and diverse material to promote and disseminate the importance of the soil to the society, as the Multilingual Soil Science Dictionary on-line. Moreover, our aim is to promote soil science among students of different stages. Thus, the creation of the SECS Award to High school students to attend the “Simposio Latinoamericano de Enseñanza y Educación en Ciencia del Suelo”; the soil science Contests for University students, the annual award to the best PhD thesis supervised by SECS members, etc. These and other examples will be exposed during the session to exchange experiences and ideas between different soil societies to promote the soil as a key compartment for sustainable development and conservation of environmental quality. The activities and services of the SECS are accessible on the web site www.secs.com.es, which is regularly updated.

Keywords: soil education, soil judging contest, soil conferences, soil comic

Acknowledgements: to the members of the Spanish Society of Soil Science



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ASSOCIATION FRANÇAISE POUR L'ÉTUDE DU SOL: 1934-2021 (FRENCH SOCIETY OF SOIL SCIENCE: 1934-2021)



www.afes.fr

Jacques Thomas* (chair), Agnès Gosselin (secretary), Denis Baize (treasurer), Christian Feller (past chair)

AFES directors (c/oINRAE, CS 400001 Ardon, F-45075 Orléans cedex 2 - France)

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Abstract

1934. Created by A. Demolon, the AFES is organized into 6 "technical sections" (Genesis, Physics, Chemistry, Biology, Soil Geography and Soil and Hygiene, Overseas) and 7 "regional sections" (North, Brittany, East, South, South-West, Massif Central, Overseas) The *Bulletin de l'AFES* was published 4 times a year.

The war stopped the AFES in its tracks. Activity did not resume until 1947 (see number of members: 173 in 1934, 405 in 1939, then 145 in 1947).

1947 was the year of the "Conférence de Pédologie méditerranéenne" (Montpellier-Alger).

1963. The revue *Science du Sol* replaced the *Bulletin de l'AFES*.

1967. The study of the spatial distribution of soils allowed the publication of the first French Soil Map at 1:1,000,000 and led to the French Classification of Soils (CPCS, 1967).

The « Service d'Étude des Sols et de la Carte Pédologique de France" was created within INRA (Institut National de la Recherche Agronomique). This activity results in the *French Soil Reference System* (RPF), published in translation and widely distributed between 1987 and 2009.

Since **1967**, the activity is centered on the organization of 2 or 3 annual scientific sessions, accompanied by publications. Diversified themes are addressed.

The AFES grew and in **1991** had more than 852 members. The activity of the technical sections decreases, the regional sections remain dynamic (indoor meetings and field trips).

Activities 1992–2020:

Communication, publications, scientific animation:

1984. Creation of the *AFES Newsletter*.

1992. The journal *Étude et Gestion des Sols* (EGS), distributed in paper form, became electronic in 1997 (free access in 2013).

1994. *Science du Sol*, along with the Belgian and British reviews *Pédologie* and *Journal of Soil Science*, ceased to be published to support the joint launch of *European Journal of Soil Science*.

The sol-Afes web list (1711 subscribers in 2020) allows many online debates.

Organization of congresses:

1998. 14th World Congress of Soil Science, Montpellier.

"National Soil Study Days" (JES), biennial, since 1989.



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"World Soil Day" (5 conferences since 2015),

Training

2003. Creation of the "Demolon Scholarships": awarded annually to thesis students (participation in international conferences).

1998. Year of the soil, AFES is very active.

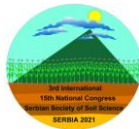
2004-2008. ISIS (Initiation of schoolchildren to soil via the Internet) project: AFES is involved in teaching about soils in secondary schools (distribution of 20,000 leaflets entitled "*Le sol, épiderme vivant de la Terre*")

2011. Creation of a "Recognition of competence in pedology" procedure awarded by a jury of AFES pedologists.

2012. 1st "AFES Webinar", currently 54 videos available.

2018. Birth of the "PromoSolsEduc" Working Group with teachers: a space for valorization and exchange of pedagogical sheets "soils".

Keywords: History of Afes 1934-2021, functioning, activities, communications, congresses, training



ENHANCING MANAGEMENT OF CONTAMINATED SITES USING ENVIRONMENTAL MONITORING DATA AND PRELIMINARY RISK ASSESSMENT METHODOLOGY IN SERBIA

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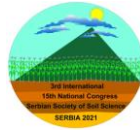
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Abstract

According to the Law on Soil Protection, the Cadastre of Contaminated Sites is a set of relevant data on endangered, polluted, and degraded soil. Serbian Environmental Protection Agency (SEPA) has been constantly working to improve the national methodology for collection, analysis and assessment of data on contaminated sites. The last updated database of the Cadastre shows that 309 potentially contaminated and contaminated sites have been identified and recorded on the territory of the Republic of Serbia. The main purpose of the Cadastre is to provide systematic data on sources of pollution such as the type, quantities, methods, and location of discharges of pollutants into the soil, in order to implement preventive or remediation measures. Data collection is defined in more detail in the Rulebook on the content and manner of keeping the Cadastre of contaminated sites, type, content, forms, manner, and deadlines for data submission. Investigation of industrial sites suspected to be contaminated was a part of the GEF-funded project Enhanced Cross-sectoral Land Management through Land Use Pressure Reduction and Planning which is implemented by United Nations Environment Programme (UNEP) in close cooperation with the Ministry of Environmental Protection and SEPA in the period 2015–2019. The main goals of the Project were to provide the lacking methodologies, knowledge, and coordination mechanisms for sustainable and integrated management of soil as a natural resource. The Project also supported further development of a Cadastre of contaminated sites and preliminary analysis of selected 32 potentially contaminated sites. Field missions to the identified sites were conducted in 2016 with the purpose to identify receptors of pollution and potential exposure routes, previous land use, surface area, type and quantity of hazardous substances found at the location and in the surrounding area, soil and groundwater quality, as well as geological, pedological and hydrological features and to prepare and elaborate sampling programs, whereas the soil sampling itself took place in 2017 when 264 soil samples were analyzed. Site specific environmental monitoring data and soil sampling results allowed performing the comparative analysis and application of preliminary risk assessment methodology that served to compile the relative risk-based priority list of 32 sites. For this purpose, the Preliminary Risk Assessment Model for the identification and assessment of problem areas for Soil contamination in Europe – PRA.MS has been applied.

Keywords: Contaminated sites, Preliminary Risk Assessment, remediation



Soils for Future under Global Challenges

THE BRITISH SOCIETY OF SOIL SCIENCE

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Abstract

The British Society of Soil Science (BSSS) will enter its 75th year in 2021. Over the last 75 years, the Society has grown from strength to strength, with over 800 members.

As the Society has grown, so too has its offer to members, with two international journals *European Journal of Soil Science* and *Soil Use and Management* and a twice-annual members' magazine, *Soil Matters*. Our conferences and events are popular with our members and monthly 'Zoom into Soil' webinars share the latest soil research and information with members and non-members alike.

The Society has recently started to offer guidance and advice to its members and the wider public, providing guidance notes on *Benefitting from Soil Management in Construction* and *Soil Land and Quality*, amongst others. The guidance will be followed by a series of 'science notes', helping governments and the public to understand the importance of soil.

The Society offers a number of grants and awards each year, particularly to support early career members to develop their careers within soil science. Funding is available via our David S Jenkinson Fellowship to support postdoctoral members to collaborate with an international organisation and the Brian Chambers Soils Fund supports early careers members with support and training in topics related to sustainable agricultural production. We also offer a range of grants and awards to support schools and colleges to teach soil science.

In 2022, BSSS will be hosting the World Congress of Soil Science in Glasgow, UK which will provide the Society with an opportunity to make an impact at an international level.

Keywords: Socio-economic, soil society, world congress



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SOCIETAS PEDOLOGICA SLOVACA

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Abstract

The establishment of the Pedological branch of the Slovak Geographical Society at the Slovak Academy of Sciences was made in 1964 in Bratislava under leading of prof. Dr. Juraj Hraško. In this paper there are showed some significant milestones of historical development of Slovak Soil Science Society: a) establishment of the Slovak Soil Science Society in 1969; b) incorporation of this society into the Slovak Society of Agricultural, Forest, Food and Veterinary Sciences in 1973 as Pedological section; c) rename of the society on Societas pedologica slovaca (SPS) in 1990; d) new legal foundation as a civil association in 1995. President of Societas pedologica slovaca is Assoc. Prof. Dr. Jaroslava Sobocká, member of the Board is prof. Dr. Jozef Kobza. The seat of Societas pedologica slovaca is located at Soil Science and Conservation Research Institute in Bratislava. SPS is also included as a Pedological section for Slovak Society for Agricultural, Forest, Food and Veterinary Sciences at Slovak Academy of Sciences. SPS is a member of International Union of Soil Sciences (IUSS) and also a member of European Confederation of Soil Sciences Societes (ECSSS). The main aims of SPS are: to organize scientific groups for development of soil science and protection of environment, promotion of scientific results of pedological research, to support of soil policy and creation of new legislative measures, to support development of international relationships and international exchange of scientific information concernig soil science and landscape protection, to help young generation of researchers and scientists through educational and pedagogical activities, to support sustainable land use. The implementation of the main activities of SPS consists of lecturing, organizing seminars, conferences. After the division of former Czech-Slovak Republic – since 1993 year, we organize together with Czech Society of Soil Science international soil science conferences named „Pedologické dni“ (Soil Science Days) alternately one year in Slovakia and second year in the Czech Republic with field excursions. There are representing their members and organizations at national and international level and cooperation between organizations in soil research and related topics, expert works and consultancy in soil science and soil conservation as well as development of publishing activities concerning the latest results of pedological research. SPS published the latest version of Morphogenetic soil classification system in Slovakia (2014). SPS has been publishing Proceedings named „Vedecké práce“ of research and scientific works yearly, but currently, since the 1-July, 2021 these were changed on the International Journal PEDOSPHERE RESEARCH. Details for contributors are listed on the website www.pedosphereresearch.sk. More activities of SPS are listed on the website www.pedologia.sk.

Keywords: Societas pedologica slovaca, history, current activities, Czech Society of Soil Science, International Union of Soil Sciences



CERES PROJECT: COUPLING EARTH OBSERVATION BASED INFORMATION AND ARTIFICIAL INTELLIGENCE FOR SOIL ORGANIC CARBON SPATIAL MODELLING

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Abstract

The use of AI in agriculture is a trend all over the world, however, in Serbia it should be especially important because agriculture is one of the crucial sectors of Serbian economy. This project will be an important step forward in the application of a wide range of relevant data generated on a daily basis and offering a huge potential for improving agricultural production and developing the concept of smart and regenerative agriculture.

The CERES project deals with the development of tools based on Artificial Intelligence (AI) algorithms intended to support agricultural production and Carbon Farming practices which result in carbon sequestration in soil and combat climate change. The idea of the project is to create models which would use big geospatial data from various sources – optical and radar satellite images (Copernicus missions), soil related data (in-situ, LandGIS, SoilGrids, LUCAS), meteorological data and textual data related to undesirable agricultural events (calamity, drought, disease, pest attack, etc) and yield estimates, available on internet portals intended for agriculture – to automatically generate new information which will help make timely and correct decisions in agriculture. The quantity of publicly available data has been growing at a massive amount and will continue to do so in the near future.

The surface reflectance and vegetation indices derived from the optical satellite imaging (Sentinel-2), soil texture derived from radar imaging (Sentinel-1), climatic variables and terrain factors will be used as covariates in order to build a predictive model for Soil Organic Carbon (SOC). Since SOC is a source of nutrients and is crucial for agricultural production, the estimated SOC stock should be very important in our models for agricultural management and yields estimates.

Given the limited amount of the available measured field data for Serbia, a distinct challenge will be how to implement the knowledge based on global models made for the wider territories (continental or regional levels) and based on open source data. As a possible solution Domain Adaptation (DA), the transfer learning technique, in which the system aims to adapt the knowledge learned from source domain, and apply it to another related domain, will be utilized to compensate “lack of data”.

Keywords: artificial intelligence, soil organic carbon, open data

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