



INTERNATIONAL UNION OF SOIL SCIENCE

**HRVATSKO TLOZNAJSTVENO  
DRUŠTVO**

**CROATIAN SOCIETY OF SOIL  
SCIENCE**



**ECSSS**

European Confederation  
of Soil Science Societies

**13.**

**KONGRES HRVATSKOG TLOZNAJSTVENOG DRUŠTVA**

***Knjiga sažetaka***

**“Potencijal tla i zemljišnih  
resursa: ključne uloge znanosti i  
učinkovitih politika”**

**13<sup>th</sup>**

**CONGRESS OF THE CROATIAN SOCIETY OF SOIL SCIENCE**

***Book of Abstracts***

**“Utilizing potential of soil and land  
resources: Key roles of science  
and effective policy”**

**10.-14.rujna 2018., Vukovar, Hrvatska**

**10.-14. september 2018., Vukovar, Croatia**







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Hotel Lav  
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*/ Ministry of Agriculture of the Republic of Croatia*



**POZVANI PREDAVAČI / INVITED SPEAKERS**



**Univ. Prof. Dr. Walter W. Wenzel,**

University of Natural Resources and Life Sciences, Vienna, Department of Forest and Soil Sciences, Institute of Soil Research, Head, Rhizosphere Ecology and Biogeochemistry Group, Austria



**Prof. Dr. Dr. h. c. Zed Rengel,**

UWA School of Agriculture and Environment, The University of Western Australia Perth, Foreign Fellow of Croatian Academy of Sciences and Arts, Australia



**Prof. Dr. Asgeir R. Almas,**

Norwegian University of Life Sciences: NMBU, Faculty of Environmental Sciences and Natural Resource Management (MINA), NO-1432 Ås, Norway



**Prof. Dr. Maja Manojlović,**

University of Novi Sad, Faculty of Agriculture, Department of Field and Vegetable Crops, Novi Sad, Serbia

## POZDRAVNA RIJEČ

Dragi kolege i prijatelji, hrvatski tloznanstvenici slijede dugu i bogatu povijest izučavanja i promoviranja održivog korištenja i zaštite tla i zemljišnih resursa. Sa zadovoljstvom vas obaviještavamo da će se 13. Kongres Hrvatskog tloznanstvenog društva s glavnom temom "Potencijal tla i zemljišnih resursa: ključne uloge znanosti i učinkovitih politika" održati od 10. do 14. rujna 2018. u Vukovaru.

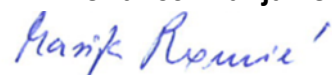
Kongres ima za cilj širiti napredne znanstvene spoznaje u području gospodarenja tlom i zemljištem, pokrivajući sva glavna tloznanstvena područja, počevši od postanka i klasifikacije tala do kakvoće tla i njegovog potencijala za proizvodnju hrane. Kongres tako nudi niz mogućnosti za predstavljanje i razmjenu ideja i iskustava u tloznanstvu i gospodarenju zemljištem koje tloznanstvena zajednica može ponuditi obrazovnim institucijama, gospodarstvu i zakonodavcima. Potrudit ćemo se u interdisciplinarnoj raspravi iznijediti perspektive i primjene inovativnih i naprednih tehnologija za održivost uloga tla u različitim područjima ljudske djelatnosti: poljoprivredi, šumarstvu, zaštiti okoliša, gospodarenju otpadom, građevinarstvu i drugim.

Zasigurno se ne može naći bolje mjesto za raspravu o tlu i njegovim ulogama u prirodi i ljudskoj civilizaciji od baroknog hrvatskog grada Vukovara. Na tom posebnom mjestu na obali Dunava plodna tla ispunjavaju sve svoje uloge, od čuvanja povijesnih i kulturnih tajni do intenzivne proizvodnje hrane. Pred nama su četiri dana predavanja, druženja i izleta u prekrasnom krajoliku i zato ćemo vas s veseljem ugostiti u Vukovaru!



S poštovanjem,

**Prof.dr.sc. Marija Romić**



Predsjednica Hrvatskog tloznanstvenog društva



## WELCOME ADDRESS

Dear colleagues and friends, Croatian soil science community follows up a long and rich tradition of studying and promoting wise and sustainable use and conservation of soil and land resources. We are pleased to inform you that the 13th Congress of Croatian Society of Soil Science with the main theme „Utilizing potential of soil and land resources: Key roles of science and effective policy“ will be held on 10-14 September 2018, in Vukovar, Croatia.

Congress intensively aims to provide an advanced scientific knowledge in soil and land management, covering all the main areas of soil science, starting from soil genesis and classification coming to soil quality and capacity for food production. Congress will provide a variety of opportunities to present and exchange ideas and expertise in soil science and land management that the soil science community may offer to educational institutions and academia, business and policy makers, gathered so far in interdisciplinary research. We'll try to gain a more well developed perspective in application of innovative and advanced technologies related to soil functions in different fields of human activities: agriculture, forestry, environment, waste management, civil engineering and other.

One can hardly find better place to discuss about soil and its roles in nature and civilization than Vukovar, Croatian Baroque city on the Danube river. In this very piece of world, fertile soil fulfills all of its functions, from hiding historical secrets to intensive food production area. We will have four days full of presentations, social events and excursions and we are looking forward to host you in Vukovar!

Sincerely,

**Prof. Marija Romić, PhD**

A handwritten signature in blue ink that reads "Marija Romić".

President of the Croatian Society of Soil Science



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## **Kisela sulfatna tla u Perth-u (Zapadna Australija) su uzrokovana smanjenjem oborina i intenzivnim pumpanjem podzemnih voda za rastuću populaciju**

Zed Rengel

*UWA School of Agriculture and Environment, University of Western Australia, Perth*

### **Sažetak**

Formiranje kiseline oksidacijom pirita i drugih sulfidnih materijala može biti posebno problematično kad se odvija duboko u profilu tla kao rezultat snižavanja razine podzemnih voda zbog pumpanja za ljudsku upotrebu. U području Perth-a (Zapadna Australija) godišnja količina oborina se smanjila za oko 30% u posljednjih 30 godina, u skladu s predviđanjima globalnih modela klimatskih promjena. Nasuprot tome, populacija Perth-a se povećala za oko 1,5 milijuna ljudi u zadnjih 20 godina, što je rezultiralo povećanim pumpanjem podzemnih voda za potrebe stanovništva i značajnim spustanjem (i do 15 m) razine podzemnih voda na Gngangara Mound (protočni sistem podzemnih voda sjeverno od Perth-a). Sedimentna tla u području Gngangara Mound-a su vrlo isprana i izuzetno podzolizirana silicijska pjeskovita tla pleistocenske starosti, s malim sadržajem karbonata i organske tvari i stoga niskim puferskim kapacitetom. Značajno snižavanje razine podzemnih voda na Gngangara Mound-u je rezultiralo oksidacijom sulfidnih materijala i organske tvari i prema tome stvaranjem kiselosti u tlu i podzemnim vodama (pH <4.0, i čak do 3.0) s povišenim koncentracijama sulfata, metaloida (As) i metala (npr. Al, Fe, Zn, Cu, Ni and Pb), i povećanim ispiranjem Ca i Mg u dublje horizonte. Vertikalni pH profili podzemnih voda su ukazali na najsnažnije zakiseljavanje na dubini od 4 do 10 m ispod površine tla. Te geokemijske promjene u tlu i podzemnim vodama su uzrokovale velike probleme (i) komunalnom poduzeću koje pumpa i distribuira vodu za potrebe stanovništva, (ii) u korištenju podzemnih voda u hortikulturnoj proizvodnji, i (iii) u gubitku bioraznolikosti (naročito u močvarnim ekosustavima koji ovise o podzemnim vodama). Mi smo razvili modelske sisteme koji povezuju biogeokemijske reakcije s transportom vode, otopina i plinova radi kvantificiranja učinka uznemiravanja potencijalnih kiselih sulfatnih tala na kvalitetu tla i podzemnih voda pod utjecajem raznih vrsta korištenja da bi pomogli u procjenjivanju prihvatljivih planova upravljanja zemljištem i smanjenja potencijalnih problema. Intenzivno i kontinuirano zakiseljavanje (pH <4) u pjeskovitim tlima s malo karbonata je uspješno modelirano na bazi oksidacije pirita uzrokovane spuštanjem razine podzemnih voda tijekom vremena. Proces zakiseljavanja je bio kontroliran dinamikom razine podzemnih voda i sadržajem organske tvari i pirita u tlu. Stupanj zakiseljavanja je bio ograničen difuzijom kisika u nezasićenoj zoni tla i stoga je bio osjetljiv na (i) vodni kapacitet tla i (ii) sadržaj organske tvari koja se natječe s piritom za kisik. Usprkos tome, zakiseljavanje pjeskovitih tala je bilo vrlo brzo nakon što su horizonti bogati piritom bili izloženi zraku, što znači da je glavni čimbenik koji kontrolira stupanj zakiseljavanja bio dinamika razine podzemnih voda. Modelirani scenariji spuštanja podzemnih voda su istaknuli potencijalnu korisnost našeg modela u ocjenjivanju rizika biogeokemijskih utjecaja na kvalitetu tla i podzemnih voda u velikom rasponu vremenskih i prostornih mjerila.

**Ključne riječi:** kisela sulfatna tla, podzemne vode, Perth





## DGT-technology applied to study the lability and uptake of P in long-term field experiments

Åsgeir Rossebø Almås

*Norwegian University of Life Sciences. Faculty of Environmental Sciences and Natural Resource Management. Post box 5003, 1432 Ås, Norway.*

### Abstract

Access to mineral phosphorus (P) is a societal issue of great concern because it is a limited resource. This is a natural consequence of the inevitable food production increase following global population growth. The fact that P is an essential and non-renewable element for all life, binding strongly in mineral soil, necessitates its precise application to field soils. Plant growth is primarily limited by insufficient N supply, but P-limitations also occur frequently. Over the years, P has been applied in excess to ensure sufficient supply to farm crops, particularly to high-intensity crops such as vegetables (Johnston et al., 2014; Pierzynski and Logan, 1993). However, erosion of such soils has resulted in increased eutrophication of low land waters (Krogstad and Lovstad, 1989; Schindler et al., 2008; Ulen et al., 2010). European countries which have committed to the EU water framework directive (EU, 2000), have implemented several means to meet the quality criteria for surface waters. Norway must reach its quality criteria by 2018. An increasing future challenge seems to be providing a sustainable and steady supply of P to feed an increasing world population (FAO, 2009; Lal, 2013), without compromising quality of low land aquatic systems. For direct assessment of trace metal and (oxy)anion availability in water, sediment and soil, the diffusive gradient in thin films (DGT) technology (Davison and Zhang, 1994) is a better alternative than classic soil extraction protocols. The DGT technology have had more than 20 years of rapid development, and its application spans from in situ measurements to speciation and kinetic studies (among other uses) of various elements in the samples of interest. The device can be placed directly in moist soil and the ions diffuse through a protective membrane, via a well-defined inert hydrogel before its being bound and accumulated to a resin. The hydrogel discriminate large dissolved molecules from diffusing through, and hence only free or labile elements are measured. The measured concentration after termination, is a time integrated concentration conditional to the ion diffusing properties and the geochemistry at the near surface of the DGT. This makes the DGT technology highly applicable for investigating in situ impacts on the fate of labile forms of components in soils as affected by external factors such as soil texture, humidity, pH, time etc. Here I am reporting some soil P partitioning and flux data collected from two long-term field trials (Ås-Norway/Rothamsted UK), based on application rates of P, using a diffusive gradients in thin films (DGT) technique and “DGT-induced fluxes in sediments” (DIFS) model. Partitioning of P in soil was accomplished by deploying DGT at increasing contact times (6 hours to 120 hours) (Almås et al., 2017). These data have been compared with P uptake in wheat harvested every week during the growth season. Finally, some soil compaction and soil humidity tests were conducted while DGT-disks were exposed at increasing contact time. In general the data showed that plants withdraw most of its P within a period of 2-3 weeks and that the intense uptake temporarily deplete the quickly labile P in soil. Plant grown on 0-P soils, however, was notably delayed in their development. This labile P was later equilibrated after the P-uptake was relaxed. Soil P load (fertilizer history) was positively related to uptake rates and masses. However, light compaction and increased soil humidity affected the P-uptake in DGT in various way, mostly in the low-P soils, and this is ascribed to soil physical conditions.



During the growth season, plants take up P from soil solution, where the P concentration in solution is controlled by rates of replenishment from larger P soil stores. This P partitioning in soil is dynamic, and geochemical factors controls P fluxes between soil solutions, from readily to slowly available to nearly unavailable P. Conceptual understanding of P partitioning and kinetic responses to external factors are used as model parameters for P: predicting uptake, managing use and agricultural efficiency (Johnston et al., 2014). But most P assessments rely on the assumption of slow redistribution kinetics; hence, equilibrium extraction methods are used most often. Extractions are easily conducted on a large number of samples with reproducible and accurate enough results to estimate plant available stores of interest. However, the use of extraction methods, such as the ammonium lactate (AL) and Olsen-P methods, conceals kinetic P release from solid to solution phases in soil as these methods primarily estimate potential plant available P stores during the growth season. Hence there is a need for a understanding the P kinetics better, in Situ, ideally without the use of extracting agents in unrealistic solid solution ratios. The DGT-technology in combination with numeric modelling provides useful parameters which can be useful for optimizing the phosphorus use efficiency, PUE, in cultivated soils.

**Key words:** DGT, phosphorus, soil, field experiments, kinetic



## Trace elements in soils and their effect on food chains

Maja Manojlović

*Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, Novi Sad, Serbia  
(maja.manojlovic@polj.uns.ac.rs)*

### Abstract

Trace elements (TEs) enter the food chain through soil enriched by weathering the geological materials or through contamination caused by industrial activities, traffic, waste deposition, and use of compost or other waste material as fertilizers. Trace elements affect plant, animal and humans in a twofold manner. Deficiency of essential TEs not only reduces crop productivity, but low TEs concentrations in plant feed and food adversely affect animal and human health. On the other hand, the accumulation of toxic TEs in soil and plants can cause the yield reduction of growing plants as well as metabolic disorders in animal and humans. Many processes are involved in the transformation of TEs in soils, controlling their bioavailability and mobility, leading that total TEs in soil in many cases do not present TEs concentrations that can be uptaken by plants. This review discusses the TEs, their sources, bioavailability, and the methodologies used for their monitoring in soil. In addition, two case studies are presented: i) one related to soil selenium (Se) deficiency affecting food chain; ii) another focused on anthropogenic influence on soils and plants in urban parks of Novi Sad (Serbia). The results show that plant Se biofortification can be good approach for the increase in Se concentrations in feed and food and confirm the importance of the study of the mobility of elements derived by anthropogenic activities since they exhibit a higher availability than that of elements of natural origin and they represent a potential risk for people health.

**Key words:** microelements, heavy metals, bioavailability, biofortification



## Copernicus Land Monitoring Service in Croatia

Andreja Steinberger

*Croatian Agency for the Environment and Nature, Radnička cesta 80, Zagreb, Croatia  
(andreja.steinberger@haop.hr)*

### Abstract

Copernicus is EU Programme for Earth Observation and Monitoring based on Sentinel satellite and in-situ data from ground stations, airborne and sea-borne sensors. It is initiated and managed by European Commission in partnership with relevant EU institutions, member states and private sector with the aim of development a set of European information services. The Copernicus Land Monitoring Service started with CORINE Land Cover (CLC) datasets, which are still, the only harmonized sources of GIS data for European territory. Through its three main components (Global, Pan-European and Local) the Copernicus Land Monitoring Service is providing free geographical information on land cover, land use, land cover and use changes, vegetation state and water cycle to users in the field of environmental and other terrestrial applications. It aims to give support in areas of spatial planning, forest management, water management, agriculture and food security and emergency management. The products of the Copernicus Land Monitoring Service at national level are produced and/or validated by Croatian Agency for the Environment and Nature under the coordination of European Environment Agency. Besides CLC datasets, there are available High Resolution Layers on land cover characteristics over the main land cover types, Urban Atlas, Riparian zones, Natura 2000 grasslands and other products in development.

**Key words:** land use, land cover, Copernicus, monitoring





## **Advanced techniques in soil surveying in the Mediterranean karst stony terraces: Case of Jadrtovac vineyards, Šibenik, Croatia**

Davor Romić

University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

### **Abstract**

Karst landscapes are widespread along the Mediterranean area, including Croatian Adriatic coast and islands. Rural area in this region, however, faces a lack of arable land. Therefore, in the last two decades more than 5000 ha of karst stony terraces and steep slopes have been remediate by stone crushing to make the land suitable for agricultural production, mostly for grapevine and olive production. After the deforestation, new grapevine and olive trees plantations are made particularly on the slopes exposed to sun and sheltered from strong winds. The program of spatial and temporal variability of soil and crop monitoring and assessment based on the integration of air- and ground-based sensors of different types and sensor data fusion was established in Šibenik, Croatian Adriatic coast where grapevine and olive trees are grown on such soil. The region benefits from Mediterranean climate with warm to hot, dry summers and frequent winds, conditions that favor organic production. Average annual precipitation of the area ranged from 557 mm to 1200 mm being quite evenly distributed over the year, and the driest from May to September. Excessively dry topsoil of stony and gravelly soils causes water run-off and thus significant evaporative loss of water. The lack of moisture was identified as an important risk indicator in grape vine and olive production. For rational use of water for irrigation, water status in plants was assessed by soil water measuring and the use of physiological indicators. Water measuring in skeletal soils is especially challenging because of the very coarse nature that pose soil contact problems for some of the available soil moisture monitoring devices, and because of great within-field variability. The maps obtained by integration of airborne thermal imagery and leaf water potential measurement are efficiently used in assessing the spatial variability of water stress across the plantations.

**Key words:** advanced techniques in soil surveying, mediterranean karst stony terraces



## The suitability of sewage sludge for soil amendment in relation to its metal and radionuclide levels

Marko Černe<sup>1</sup>, Igor Palčić<sup>2</sup>, Igor Pasković<sup>1</sup>, Nikola Major<sup>1</sup>, Marija Romić<sup>2</sup>, Marina Diana Igrc<sup>2</sup>, Aleksandra Perčin<sup>2</sup>, Smiljana Goreta Ban<sup>1</sup>, Benjamin Zorko<sup>3</sup>, Branko Vodenik<sup>3</sup>, Denis Glavič Cindro<sup>3</sup>, Dean Ban<sup>1</sup>

<sup>1</sup>Institute of Agriculture and Tourism, Karla Huguesa 8, 52440 Poreč, Croatia (marko@iptpo.hr)

<sup>2</sup>University of Zagreb Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia

<sup>3</sup>Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia

### Abstract

The aim of this study was to evaluate the suitability of sewage sludge for soil amendment in relation to its metal and radionuclide levels. The macronutrients were assayed as they may affect the retention of contaminants by sludge biomass. In the dewatered sewage sludge, the contents of total N, P and K were determined using the ISO recommended procedures. Concentrations of total Cd, Ni, Zn were measured using the ICP-OES, while <sup>238</sup>U and <sup>226</sup>Ra by gamma-ray spectrometry. The results showed that N contents ranging from 0.4–7.7%, while the amounts of P and K were within the limits from 3.2–36.1 and 0.8–4.7 g kg<sup>-1</sup> d.w., respectively. Concentrations of Cd, Ni and Zn varied from 0.3–1.3, 7.9–52.6 and 95.7–1254.0 mg kg<sup>-1</sup> d.w., respectively, which is below the threshold limits according to Croatia's legislative on sewage sludge agricultural use. Concentrations of <sup>238</sup>U and <sup>226</sup>Ra, which ranged from 8.7–59.1, and 3.2–44.5 Bq kg<sup>-1</sup> d.w., respectively, are in the area of a natural background. Furthermore, the correlations between the N and Cd ( $r = 0.755$ ) and P and <sup>238</sup>U ( $r = 0.668$ ) indicate that macronutrient compounds may be involved in adsorption of metal contaminants by municipal sludge. According to obtained results it seems that studied municipal bio-solids may be applied to soil considering the legislative-based recommendation. Soil conditioning with sewage sludge may be a promising strategy for nutrient recycling from municipal waste.

**Key words:** soil amendment, sewage sludge, macronutrients, metals, radionuclides



## Applicability of the $k_0$ -INAA for soil samples

Radojko Jaćimović<sup>1</sup>, Marko Černe<sup>2</sup>, Dean Ban<sup>2</sup>

<sup>1</sup> *Jožef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia ([radojko.jacimovic@ijs.si](mailto:radojko.jacimovic@ijs.si))*

<sup>2</sup> *Institute of Agriculture and Tourism, Karla Huguesa 8, 52440 Poreč, Croatia ([marko@iptpo.hr](mailto:marko@iptpo.hr) and [dean@iptpo.hr](mailto:dean@iptpo.hr))*

### Abstract

Neutron activation analysis (NAA) is a nuclear analytical technique that utilises the specific properties of nuclear reactions, thereby enabling simultaneous determination of numerous elements in a sample. Due to its sensitivity, versatility and high reliability, NAA is the most prominent of all the activation techniques. The idea of using the  $k_0$ -method of instrumental neutron activation analysis ( $k_0$ -INAA) for analytical purposes appeared in the early 1970s, where the absolute nuclear data are replaced with  $k_0$ -factors that are experimentally determined. It uses Au as the standard (Al-0.1% Au alloy) irradiated together with a sample and nuclear composite nuclear constants for analytically interesting nuclides are normalised to Au nuclear data. The  $k_0$ -method at the Department of Environmental Sciences of the Jožef Stefan Institute (IJS) has been introduced in the middle 1990s and validated, and since then it has been used for routine analyses for determining micro and trace elements in different environmental samples. In addition, the  $k_0$ -INAA at the 250 kW TRIGA Mark II research reactor of the IJS has been accredited according to the ISO 17025 for determining elemental composition in environmental samples since 2009. In this work, the  $k_0$ -INAA technique was applied for determination of minor and trace elements in samples of sewage sludge-amended soil. Some preliminary results of the study will be presented and discussed.

**Key words:** soil, NAA,  $k_0$ -INAA, TRIGA reactor



## Financial Value of Soils in Eastern Part of Croatia due to the Soil Fertility

Milan Mesić, Aleksandra Perčin, Igor Bogunović, Željka Zgorelec, Ivana Šestak

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (mmesic@agr.hr)*

### Abstract

In order to propose a financial valorisation of soil based on nutrients supply five soil types (Gleysoils; Gleysoils, Mollic; Cambisol; Eutric Cambisol; Chernozem Haplic) were selected in Eastern Slavonia, Croatia. Price calculation for one hectare of arable land included the summation of nutrient content [total nitrogen (kg N/ha), plant available phosphorus (kg P<sub>2</sub>O<sub>5</sub>/ha) and potassium (kg K<sub>2</sub>O/ha)] and organic matter content (kg OM/ha) in soil to the depth of 90 cm as well as the proposal of price for a particular parameter. Carbon recalculated from humus was valorized due to a stock price of CO<sub>2</sub> in emissions trades (1 t CO<sub>2</sub> = 12.73 EUR; 1 t C = 3.47 EUR), nitrogen due to urea price (1 t of Urea = 197.24 EUR; 1 t N = 90.6 EUR) and the proposed prices for P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were 1 EUR/kg of nutrient. According to the nutrient status in soil and suggested prices 1 hectare arable Gleysoils, Mollic in Belje area would have a price of 6012 EUR and Gleysoils of 4723 EUR. In Vukovar area 1 hectare of arable Eutric Cambisol would cost 5526 EUR while Chernozem Haplic 5197 EUR. In the vicinity of Vinkovci city 1 ha hectare of arable Cambisols was evaluated for 5033 EUR and Gleysoils for 5344 EUR.

**Key words:** Gleysoils, Cambisols, Chernozem, carbon, nutrients status





## Selen u tlima istočne Hrvatske

Zdenko Lončarić, Vladimir Ivezić, Darko Kerovec, Brigita Popović, Krunoslav Karalić,  
Vladimir Zebec, Domagoj Rastija

*Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira  
Preloga 1, Osijek, Hrvatska*

### Sažetak

Selen je esencijalni element za životinje i ljude, ne i za biljke, ali nedostatak Se u tlima rezultira nedostatkom u prehrambenom lancu, prvenstveno u hrani biljnog podrijetla uz pothranjenost ljudi. Zbog toga se koncentracije ukupnog Se u tlima  $<500 \mu\text{g kg}^{-1}$  smatraju nedostatkom Se. Pošto područje Hrvatske, a posebno kontinentalni dio, pripada prostorima s niskim koncentracijama Se, u ovom su radu analizirani odnosi osnovnih agrokemijskih svojstava tala i ukupne koncentracije Se. Analizirano je 354 uzorka oraničnog sloja tala u Osječko-baranjskoj i Vukovarsko-srijemskoj županiji. Utvrđen je širok raspon trenutne ( $\text{pH}_{\text{H}_2\text{O}}$  4,39-8,67) i izmjenjive kiselosti ( $\text{pH}_{\text{KCl}}$  3,74-8,33), sadržaja organske tvari tla ( $6,5\text{-}48,8 \text{ g kg}^{-1}$ ), te ukupnih i raspoloživih hraniva. Koncentracije ukupnog Se su u rasponu  $87\text{-}516 \mu\text{g kg}^{-1}$  uz prosjek  $237 \mu\text{g kg}^{-1}$ , što iznosi samo 47 % dostatne opskrbljenosti tla. Pri tome je u samo jednom tlu utvrđeno više od  $500 (516) \mu\text{g Se kg}^{-1}$ , što je ujedno i tlo s najvećim sadržajem organske tvari ( $48,8 \text{ g kg}^{-1}$ ). U preostalih 99,7 % uzoraka je  $<500 \mu\text{g Se kg}^{-1}$ , a čak u 287 uzoraka (81,1 %)  $<0,3 \mu\text{g kg}^{-1}$ . Utvrđena je značajna pozitivna korelacija ( $r=0,2368$ ;  $P<0,0001$ ) sadržaja organske tvari i Se u tlu, te je prosječno najmanje Se ( $208 \mu\text{g kg}^{-1}$ ) utvrđeno u tlu s  $<1$  % organske tvari, a porastom sadržaja organske tvari na 1-2, 2-3, 3-4 i  $>4$  % povećan je i sadržaj Se na 225, 244, 255 i  $355 \mu\text{g kg}^{-1}$ . Sadržaj Se je u značajnoj negativnoj korelaciji s pH vrijednostima tla ( $r_{\text{pH}_{\text{KCl}}}=-0,2573$ ). U kiselim tlima s  $\text{pH}_{\text{KCl}} < 5$  utvrđeno je prosječno 252, a u tlima s  $\text{pH}_{\text{KCl}} > 7,5$  samo  $137 \mu\text{g Se kg}^{-1}$ . Međutim, veće koncentracije ukupnog Se u kiselim tlima niti su iznad granične vrijednosti nedostatka Se, niti su pokazatelj dostatnosti jer se porastom kiselosti smanjuje raspoloživost Se. Pozitivne korelacije s organskom tvari tla ukazuju da se očuvanjem humoznosti tla i organskom gnojdbom može smanjiti nedostatak Se u tlima.

**Ključne riječi:** ukupni selen, humoznost, pH tla, pothranjenost, nedostatak selena



## Postanak, razvoj i sedimentne značajke delti rijeka Mirne i Neretve

Igor Felja, Mladen Juračić

*Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu, Horvatovac 102a, Zagreb, Hrvatska  
([igorfelja@geol.pmf.hr](mailto:igorfelja@geol.pmf.hr); [mjuracic@geol.pmf.hr](mailto:mjuracic@geol.pmf.hr))*

### Sažetak

Rijeke Mirna i Neretva, za razliku od većine istočno-jadranskih krških rijeka, istaložile su tijekom holocena velike količine materijala na svojim ušćima i stvorile delte koje su postupno, u zadnjih 7500 godina, ispunile nekadašnje krške estuarije. Na temelju sedimentoloških i mikropaleontoloških karakteristika sedimentnih jezgri izvađenih iz detinih ravnica rijeka Mirne i Neretve, rekonstruirani su taložni okoliši, od estuarijskih tijekom ranog holocena, pa postupnog zapunjavanja estuarija i progradacije estuarijskih delti, stvaranja prijelaznih brakičnih okoliša, do današnjih deltnih ravnica. Iako su mehanizmi i tijek nastanka današnjih deltnih ravnica u nekadašnjim krškim estuarijima Mirne i Neretve slični, postoje razlike u sedimentnom zapisu koji su posljedica različite litologije drenažnog područja ovih dviju rijeka. Sedimenti istaloženi u estuariju Mirne su sitnozrnati muljevi (frakcije praha i gline) što je posljedica trošenja fliških naslaga (lapora) kroz koje Mirna prolazi. Rijeka Neretva drenira područje s različitim tipovima stijena što je za posljedicu imalo donos veće količine materijala, ali također i nešto krupnozrnatijeg materijala (pijesak i prah). Deforestacija tijekom prošlosti u dolini Mirne te izgradnja brana na Neretvi pokazuju kako je utjecaj čovjeka, uz prirodne procese, važan čimbenik u razvoju/degradaciji deltnih područja. Gubitak ekološki vrijednih močvarnih područja te salinizacija obradivih tla i vodonosnika najveći su problem današnjih delti.

**Ključne riječi:** krški estuariji, estuarijske delte, holocen, taložni okoliši.



## Mineralogical and geochemical characteristics of soil in vicinity of Zagreb wastewater company

Stanko Ružičić, Jelena Trebeš

*Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Pierottijeva 6, Zagreb, Croatia (stanko.ruzicic@rgn.hr)*

### Abstract

The main goal of this study was to determine mineralogical and geochemical characteristics of soil in vicinity of Zagreb wastewater company situated in the eastern part of Zagreb, Croatia in order to better understand the distribution of mineral phases and heavy metal concentration in the study area. Soil samples were collected from 8 different locations, of which one is made of a vertical profile of depth up to 80 cm. Numerous laboratory methods have been performed on soil samples, including determination of color, pH value and electrical conductivity, CaCO<sub>3</sub> content, organic matter content, texture analysis, sequential extraction analysis (BCR), atomic absorption spectroscopy (AAS), cation exchange capacity (CEC) and X-ray diffraction analysis (XRD). The soil is determined as Fluvisol. pH values are neutral to slightly basic. Soil texture is determined as silty to sandy loam. The main mineralogical compound of analyzed soil are carbonate minerals and quartz. In clay fraction of soil lesser than 2 μm, chlorite and illite prevails. It was found that Cr, Ni and Cd exceeded MAC values and therefore represent potential environmental hazards.

**Key words:** heavy metals, soil mineralogy, industrial contamination, Zagreb wastewater company



## Prikladnost metoda određivanja KIK-a u ovisnosti o značajkama tla

Željka Zgorelec<sup>1</sup>, Branka Grahovac<sup>2</sup>, Aleksandra Perčin<sup>1</sup>, Vlatka Jurković<sup>2</sup>, Lola Gandjaeva<sup>3</sup>,  
Nada Maurović<sup>1</sup>

<sup>1</sup>Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska ([zzgorelec@agr.hr](mailto:zzgorelec@agr.hr))

<sup>2</sup>Hrvatski centar za poljoprivredu, hranu i selo, Svetošimunska 25, Zagreb, Hrvatska

<sup>3</sup>ERASMUS student, Urgench State University, Khamid Alimjan 14, 220100 Urgench, Uzbekistan

### Sažetak

Izmjena iona značajan je proces u tlu, koji obuhvaća adsorpciju, desorpciju i zamjenu kationa i aniona iz otopine tla na pozitivno ili negativno nabijenu površinu čestica tla. Kationsko izmjenjivački kapacitet (KIK) je parametar koji nam pokazuje u kojoj su mjeri zastupljena mjesta na površini tla koja potencijalno mogu zadržati katione elektrostatičkom silom. Kod različitih tipova tala dolazi do variranja u KIK-u što ovisi o mnogim faktorima (pH, tekstura, sadržaj organske tvari). KIK je dobar indikator kvalitete i plodnosti tla. KIK se može mjeriti pomoću različitih metoda i teško je preporučiti univerzalnu metodu. Najčešće korištene metode obuhvaćaju zamjenu kationa s određenom otopinom poznatih koncentracija soli, onih kationa kojih nema u tlu ( $\text{BaCl}_2$ ,  $\text{CH}_3\text{COONH}_4$ ,  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ ,  $\text{AgSC}(\text{NH}_2)_2$ ), te zatim analitičko određivanje (detekcija) tih kationa standardnim tehnikama. Zbog različitih metoda mjerenja KIK-a važno je znati namjenu korištenja podataka. U ovom radu cilj je bio utvrditi i usporediti KIK i količinu zamjenjivih kationa ( $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$  i  $\text{Mg}^{2+}$ ) izmjerenih na istim uzorcima tla ( $n=50$ ) različitih karakteristika, dvjema metodama (s otopinom  $\text{BaCl}_2$  - HRN ISO 11260:2004 i s otopinom  $\text{CH}_3\text{COONH}_4$  - metoda treskanja, NF X 31-108:2002) u dva različita laboratorija (Agronomski fakultet i Agencija za poljoprivredno zemljište), te utvrditi njihovu ovisnost sa reakcijom tla, sadržajem organske tvari i sadržajem gline.

**Ključne riječi:** barijev klorid, amonijev acetat, pH, tekstura, organska tvar



## Appropriateness of CEC determination methods regarding the soil properties

Zeljka Zgorelec<sup>1</sup>, Branka Grahovac<sup>2</sup>, Aleksandra Percin<sup>1</sup>, Vlatka Jurkovic<sup>2</sup>, Lola Gandjaeva<sup>3</sup>, Nada Maurović<sup>1</sup>

<sup>1</sup>Faculty of Agriculture University of Zagreb, Svetošimunska 25, Zagreb, Croatia ([zzgorelec@agr.hr](mailto:zzgorelec@agr.hr))

<sup>2</sup>Croatian center for agriculture, food and rural affairs, Svetošimunska 25, Zagreb, Croatia

<sup>3</sup>ERASMUS student, Urgench State University, Khamid Alimjan 14, 220100 Urgench, Uzbekistan

### Abstract

Exchange of ions is a significant process in the soil, which involves adsorption, desorption and substitution of cations and anions from soil solution to a positive or negatively charged soil particles surface. Cation Exchange Capacity (CEC) is a parameter which reveals extent of the soil surface sites that can potentially retain cations by electrostatic forces. Different soil types vary in CEC values which depend on many factors (pH, texture, organic matter content). CEC is a good indicator of soil quality and fertility. CEC can be measured using different methods and it is difficult to recommend a universal method. The most commonly used methods include exchange of cations with a specific solution of known salt concentrations which are not present in the soil ( $\text{BaCl}_2$ ,  $\text{CH}_3\text{COONH}_4$ ,  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$ ,  $\text{AgSC}(\text{NH}_2)_2$ ), and then analytical detection of these cations by standard techniques. Due to various methods of measuring CEC, it is important to know the purpose of data usage. In this paper, the aim was to determine and compare the CEC and the amount of exchangeable cations ( $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ ) measured on the same soil samples ( $n = 50$ ) with different characteristics, using two methods (with  $\text{BaCl}_2$  solution - HRN ISO 11260:2004 and with  $\text{CH}_3\text{COONH}_4$  solution - agitation method, NF X 31-108:2002) in two different laboratories (Faculty of Agriculture and Agency for Agricultural Land), and to determine their dependence with soil reaction, content of organic matter and clay content.

**Key words:** barium chloride, ammonium acetate, pH, texture, organic matter



## Examples of the use of soil micromorphological features as indicators of soil moisture regime

Vedran Rubinić<sup>1</sup>, Goran Durn<sup>2</sup>, Stjepan Husnjak<sup>1</sup>

<sup>1</sup>*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (vrubinic@agr.hr)*

<sup>2</sup>*Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Perottijeva 6, Zagreb, Croatia*

### Abstract

Soil moisture regime (SMR) involves entry of water into soil, its movement/stagnation, and its consumption or its exit from the soil. Largely, SMR is the function of climate, vegetation, relief, groundwater level, and soil properties (e.g., texture, structure, and content of humus). Given that SMR is one of the key factors affecting the productivity of agricultural soils, determining its characteristics is important. This can be done by using special (often expensive) devices and/or by long-term sampling and measurement of soil water retention/movement. However, with adequate knowledge and experience, SMR can be determined also in a faster and cheaper manner - by studying soil morphology and soil micromorphology. While the former is analyzed in the field by naked eye (or by hand-lens), the latter is analyzed in impregnated soil samples (thin sections) using a petrographic microscope. Our aim was to present some possibilities of using micromorphological soil features as SMR indicators. Selected soil profiles/horizons showing redoximorphic features (RMF) as signs of excessive wetting were analyzed. Results have shown the high potential of using RMF as indicators of SMR. However, sometimes it may be important to distinguish the recent RMF, formed in line with the actual SMR, from the older (potentially relict) ones. This distinction is more reliable when not based exclusively on field soil morphology, but also on soil thin sections micromorphology.

**Key words:** soil moisture regime, soil morphology, soil redoximorphic features





## Estimation of water repellency effect on soil hydraulic properties in a burned forest site

Vilim Filipović<sup>1</sup>, Mirel Mešić<sup>1</sup>, Thomas Weninger<sup>2</sup>, Andreas Schwen<sup>2</sup>, Lana Filipović<sup>1</sup>

<sup>1</sup>University of Zagreb, Faculty of Agriculture, Department of Soil Amelioration, Svetošimunska 25, 10000 Zagreb, Croatia (vfilipovic@agr.hr)

<sup>2</sup>University of Natural Resources and Life Sciences Vienna (BOKU), Institute of Hydraulics and Rural Water Management, Muthgasse 18, 1190 Vienna, Austria.

### Abstract

Soil water repellency (SWR) is a phenomenon usually caused by the presence of various hydrophobic coatings on soil particles and/or drying conditions, possibly leading to a significant reduction of soil water infiltration capacity. For example, forest fires may cause a SWR, known as a “fire induced SWR”, by exposing the soil organic particles to the extreme temperatures and resulting in their hydrophobicity or a formation of hydrophobic coatings on the nearby mineral particles. Thus, the goal of this research was to estimate the SWR possibly occurring after the forest fire and its potential effects on soil hydraulic properties. Field measurements were performed near Šibenik (Croatia) in 2016, after a large pine forest fire on three selected locations, differing in the severity of burning (A-heavily burned, B-burned and C-control). Tension disc infiltration measurements with water and ethanol were conducted, after which an inverse modeling of the infiltration experiments using the HYDRUS suite was performed to numerically estimate soil hydraulic parameters. Infiltration experiments showed differences between the measurements with water and ethanol, indicating the presence of SWR. A large effect of SWR on saturated hydraulic conductivity ( $K_s$ ) was observed. The change of  $K_s$  can significantly influence water flow and balance in the soil, by different water distribution between infiltration, surface runoff and seepage.

**Keywords:** forest fire, soil water balance, hydrophobicity, numerical modeling



## **Influence of soil composition on soil microbiome in phosphorus depleted artificial soils**

Irina Tanuwidjaja<sup>1,2</sup>, Cordula Vogel<sup>3,4</sup>, Geertje J. Pronk<sup>3,5</sup>, Ingrid Kögel-Knabner<sup>3</sup>, Stefanie Schulz<sup>2</sup>, Mirna Mrkonjic Fuka<sup>1</sup>, Michael Schloter<sup>2</sup>

<sup>1</sup> Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia  
(ianuwidjaja@agr.hr)

<sup>2</sup> Research Unit Comparative Microbiome Analysis, Helmholtz Zentrum München, Ingolstädter Landstraße 1, Oberschleißheim, Germany

<sup>3</sup> Chair of Soil Science, Technical University of Munich, Emil-Ramann-Str. 2, Freising-Weißenstephan, Germany

<sup>4</sup> Institute of Soil Science and Site Ecology, Dresden University of Technology, Piennner Strasse 19, Tharandt, Germany

<sup>5</sup> Ecohydrology Research Group, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada

### **Abstract**

In soil the interaction between microbes and soil constituents, such as clay minerals and organic matter result in the formation of highly reactive interfaces, that represent hotspots of microbial diversity and activity, such as phosphorus (P) turnover. In this experiment we studied the influence of clay minerals on microbial diversity and structure as well as resulting influence on P turnover. Two artificial soils (AS) that varied in clay minerals (montmorillonite and illite) were investigated. Both AS were inoculated with microorganisms from agricultural soil and sterile manure and incubated under controlled laboratory conditions for 842 days. Shotgun metagenomics sequencing approach was selected. We observed the establishment of highly diverse microbiome whose structure was dependent on clay minerals which could be attributed to their physical and chemical properties, interaction with organic matter and consequent nutrient availability. In addition, high potential for P mineralization and uptake developed in answer to the P depletion after prolonged maturation of AS. Different strategies were present in different AS, expression of pyrophosphatase and exopolyphosphatase and *pstSCAB* transporter in montmorillonite and alkaline phosphatase and *ugpBAEC* transporter in illite. This study confirmed that the clay minerals have a major role in selecting and shaping of microbial communities and that the phosphorus depletion drives the soil microbiome towards P recycling.

**Keywords:** phosphorus depletion, soil microbiome, artificial soils, clay minerals



## Change of soil organic carbon stocks and the calculation of total N and SOC trends, and C:N ratio

Andreja Steinberger<sup>1</sup>, Branka Grahovac<sup>2</sup>, Slobodan Miko<sup>3</sup>, Hrvoje Marjanović<sup>4</sup>.

<sup>1</sup>Croatian Agency for the Environment and Nature, Radnička cesta 80, Zagreb, Croatia (andreja.steinberger@haop.hr)

<sup>2</sup> Croatian center for agriculture, food and rural affairs; Vinkovačka cesta 63c, 31 000 Osijek (branka.grahovac@hcphs.hr)

<sup>3</sup>Croatian Geological Survey, Sachsova 2, P.O.Box 268, 10000 Zagreb (slobodan.miko@hgi-cgs.hr)

<sup>4</sup>Croatian Forest Research Institute, Cvjetno naselje 41, 10450 Jastrebarsko (hrvojem@sumins.hr)

### Abstract

Soil survey and monitoring are becoming increasingly important in fulfilling reporting obligations to the United Nations Framework Convention on Climate Change (UNFCCC). Carbon stocks and stock change, status and trends of SOC, total N and C:N ratio, have to be reported annually in relation to GHG emissions. Land use and land management practices on national level, and not only for agricultural land, are also the key issues that need to be taken into account in SOC measurements and soil parameters analyses. In order to fulfill national reporting obligations and improve environmental monitoring data, in 2014, Croatian Agency for the Environment and Nature initiated the project “Change of soil organic carbon stocks and the calculation of total N and SOC trends, and C:N ratio”. Soil was sampled at 725 locations of representative land uses and depths from 0 to 30 cm. Soil sampling, physical and chemical laboratory analyses and data analyses are conducted in accordance to 2006 IPCC Guidelines for National Greenhouse Gas Inventories. All project results are included in GIS database containing spatial data, physical and chemical soil properties and analyzed data. Project results can be viewed or downloaded at ENVI Environment Atlas.

**Key words:** SOC, carbon stock, UNFCCC, environment



## Zalihe organskog ugljika u šumskoj prostirci i tlu prašume hrasta lužnjaka Prašnik

Darko Bakšić<sup>1</sup>, Nera Bakšić<sup>1a</sup>, Dino Buršić<sup>1b,2</sup>, Alen Juzbašić<sup>1b</sup>, Ivan Perković<sup>1</sup>, Nikola Pernar<sup>1</sup>, Vibor Roje<sup>1</sup>

<sup>1</sup>Šumarski fakultet Sveučilišta u Zagrebu, Zavod za ekologiju i uzgajanje šuma, Svetošimunska 25, Zagreb, Hrvatska ([dbaksic@sumfak.hr](mailto:dbaksic@sumfak.hr))

<sup>1a</sup>Šumarski fakultet Sveučilišta u Zagrebu, Zavod za ekologiju i uzgajanje šuma – bivši student doktorskog studija

<sup>1b</sup>Šumarski fakultet Sveučilišta u Zagrebu, Zavod za ekologiju i uzgajanje šuma – bivši student diplomskog studija

<sup>2</sup>Hrvatski šumarski institut, Centar za općekorisne funkcije šuma „Josip Ressel“ u Pazinu, 154. Brigade Hrvatske vojske bb, 52000 Pazin, Hrvatska (sadašnja adresa)

### Sažetak

Globalno zagrijavanje u posljednjih nekoliko desetljeća potaknulo je brojna znanstvena istraživanja u kojima je utvrđen pozitivan učinak šumskih ekosustava kao značajnih ponora atmosferskog ugljika. Prašumski ekosustavi u kojima nema gospodarskih aktivnosti idealni su za istraživanje i razumijevanje prirodnih zakonitosti te kao takvi predstavljaju referentna stanja zaliha i bilanci ugljika. Cilj istraživanja bio je utvrditi prostornu distribuciju ugljika u šumskoj prostirci i tlu na području prašume hrasta lužnjaka Prašnik, kao i dati odgovor na pitanje postoji li razlika između zaliha ugljika u šumskoj prostirci i tlu s obzirom da se na razmjerno malom prostoru (53 ha) javljaju dvije zajednice: hrast lužnjak s velikom žutilovkom i rastavljenim šašem (*Genisto elatae-Quercetum roboris caricetosum remotae* Horvat 1938) – Ge-Qr i hrast lužnjak i obični grab (*Carpino betuli-Quercetum roboris „tipicum“* Rauš 1973) – Cb-Qr. Zajednica Ge-Qr ima statistički značajno veću zalihu ugljika u šumskoj prostirci  $5,28 \pm 3,46$  Mg ha<sup>-1</sup> i u tlu do 1 m dubine  $215,3 \pm 52,9$  Mg ha<sup>-1</sup> u odnosu na Cb-Qr koja u šumskoj prostirci ima  $3,12 \pm 1,42$  Mg ha<sup>-1</sup>, a u tlu  $130 \pm 30,6$  Mg ha<sup>-1</sup>. Navedene razlike mogu se pripisati specifičnim mikrostanišnim prilikama uvjetovanim različitim režimom vlaženja koji utječe na sastav zajednica, a na taj način i na ukupnu produkciju te brzinu razgradnje organske tvari. Istraživanja su obavljena u okviru projekta CroFEM.

**Ključne riječi:** ugljik, tlo, šumska prostirka, prašuma hrasta lužnjaka



## Utjecaj sastojina kultura obične smreke (*Picea abies* L., H. Karst.) na tlo

Ivan Perković, Nikola Pernar, Darko Bakšić, Vibor Roje

Šumarski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, 10000 Zagreb, ([iperkovic@sumfak.hr](mailto:iperkovic@sumfak.hr))

### Sažetak

Cilj ovog istraživanja je na temelju kvantitativnih pedofiziografskih pokazatelja tla determinirati promjene u tlu koje se pripisuju utjecaju smrekovih kultura. Istraživanja su provedena u središnjem i sjeverozapadnom dijelu Hrvatske (na osam lokaliteta), gdje su se kulture smreke značajno podizale u drugoj polovici 20. Na svakom lokalitetu u smrekovoj kulturi je otvoren pedološki profil radi određivanja endomorfoloških parametara tla, dok su u smrekovoj kulturi i prirodnim sastojinama u njihovoj neposrednoj blizini uzeti kompozitni uzorci tla iz dvije dubine (od 0 do 10; 10 do 20 cm) i šumska prostirka za analizu razlika između istraživanih ploha. Na prikupljenim uzorcima tla određeni su sljedeći pedofiziografski pokazatelji: količina šumske prostirke, granulometrijski sastav tla, pH-vrijednost u H<sub>2</sub>O i 0,01 M CaCl<sub>2</sub>, udjel C<sub>org</sub>, udjel N<sub>tot</sub> te udjel mobilnih hraniva (Mehlich III). Rezultati istraživanja pokazuju da je na svim lokalitetima u kulturama smreke veća količina šumske prostirke u odnosu na prirodne sastojine. U mineralnom dijelu tla pH-vrijednost je na većini lokaliteta niža u kulturama smreke. Glavni doprinos istraživanja je evaluacija melioracijskog učinka kultura smreke na tlo, što će predstavljat pouzdani oslonac u donošenju odgovarajućih odluka u planiranju specifičnih zahvata u staništu, kakav je i podizanje šumske kulture.

**Ključne riječi:** kulture smreke, prirodne sastojine, svojstva tla, šumska prostirka



## Agricultural land recultivation after gravel depository

Vesna Zupanc, Helena Grčman, Marko Zupan

*Biotechnical faculty, University of Ljubljana, Jamnikarjeva 101, 1000 Ljubljana, Slovenia  
(marko.zupan@bf.uni-lj.si)*

### Abstract

During construction of infrastructure, mid to short-term non-agricultural land use occurs on agricultural lands, such as gravel depository. Upon return to agricultural use, negative consequences such as soil compaction and reduction of soil production potential have to be remedied by recultivation. Recultivated areas are recurrently found in poor condition due to low-quality and inappropriate engineering or poor land husbandry. Problems can evolve from natural soil-forming processes, i.e. eluvial-illuvial process of the soil's fine particles, which decreases permeability and increases bulk density or are caused by recultivation activities such as maneuvering of the soil in stockpiles or levelling of the layer surfaces. In this paper, recultivation denotes the process of re-applying soil layers and fertilization. The goal of this study was to assess soil quality and production potential of area after gravel depository. In the presented case study, recultivation measures comprised of re-application of soil layers, which facilitated restoration of the damaged agricultural land. For sufficient improvement of soil structure which would enable vertical water flow, meliorative plant cover would be needed. Attention must be given to initial topographic form which should enable sufficient surface water runoff. Because of poor or non-existent soil structure, and thus poor hydraulic conditions immediate intensive land use is not possible. For successful rehabilitation, meliorative plant cover should last at least five years.

**Key words:** recultivation, agricultural land, soil degradation, technosol, meliorative measures, soil production potential



## Pogodnost metode višestruke ekstrakcije za određivanje organskog fosfora u poljoprivrednim tlima

Brigita Popović<sup>1</sup>, Zdenko Lončarić<sup>1</sup>, Meri Engler<sup>1</sup>, Jurica Jović<sup>1</sup>, Anamarija Dellavia<sup>2</sup>

<sup>1</sup>Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira Preloga 1, Osijek, Hrvatska (bpopovic@pfos.hr)

<sup>2</sup>HEP, Odjel za kemijsku tehnologiju – laboratorij KPV, Zagorska 1, Zagreb, Hrvatska

### Sažetak

Organski fosfor tla predstavlja više od 50 % ukupnog fosfora te se može naći u obliku velikog broja kemijskih spojeva, većinom u obliku inositol penta i hekso fosfata vezanih željezom i aluminijem. Cilj rada bio je utvrditi pogodnost metode za analizu organskog fosfora u tlu te prikazati ukupni potencijal organskog fosfora u tlima istočne Slavonije. S obzirom da na sadržaj organskog fosfora u tlu ima veliki utjecaj sadržaj humusa, dopunski cilj rada bio je utvrditi korelacije između osnovnih svojstava tla i sadržaja organskog fosfora. Organski fosfor u tlu utvrđen je metodom trostupanjske ekstrakcije: ekstrakcija s NaHCO<sub>3</sub>, ekstrakcija s HCl, ekstrakcija s NaOH-a. Uz ekstrakciju provodio se i analitički postupak digestije, a koncentracija fosfora dobivena pojedinom frakcijom izračunata je putem formule  $P(\text{mg/kg}) = \text{koncentracija } P(\text{mg/l}) \times (\text{volumen ekstrakta (l)} / \text{masa tla (kg)})$ . Korelacijom je utvrđen visoki stupanj međuovisnosti ova dva postupka za sve tri ekstrakcije ( $r=0,78$ ). Isto tako, utvrđene su korelacije između ukupnog i mineralnog fosfora u tlu pri čemu je u prvoj ekstrakciji utvrđena korelacija iznosila  $r=0,84$ , u drugoj  $r=0,98$ , te u trećoj  $r=0,70$ . Treća ekstrakcija s NaOH koja predstavlja stabilni kemijski vezani fosfor imala je najveće utvrđene vrijednosti organskog fosfora koje su se kretale se u rasponu od 278,50 mg/kg do 579,50 mg/kg s prosjekom od 370,85 mg/kg. Trostupanjska ekstrakcija pokazala se kao pouzdana metoda za određivanje sadržaja organskog fosfora, može koristiti za tumačenje utjecaja humusa i mineralnog fosfora na frakciju organskog fosfora u tlu.

**Ključne riječi:** organski fosfor, ekstrakcija, digestija



## Osvrt na granične vrijednosti onečišćenih tehnogenih tala na primjeru sanacija benzinske postaje

Ivica Kisić<sup>1</sup>, Sanja Mesić<sup>2</sup>, Kristina Marković<sup>2</sup>, Antonija Jonjić<sup>1</sup>

<sup>1</sup>*Agronomski Fakultet Zagreb Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska (ikisic@agr.hr)*

<sup>2</sup>*INA-Industrija nafte, d.d., Avenija Većeslava Holjevca 10, p.p. 555, 10 020 Zagreb, Hrvatska*

### Sažetak

Tehnogena tla su tla nastala primarno ljudskom djelatnošću u gradskim sredinama pri izgradnji zgrada, tvornica, cesta i drugih objekata, premještanjem i miješanjem horizonata prirodnog tla. Takva tla su, između ostalog, determinirana i u okruženju benzinskih postaja. Prema prihvaćenoj zakonskoj regulativi (Zakon o zaštiti okoliša: NN 80/13, 153/13, 78/15. i Zakon o rudarstvu: NN 56/13 i 14/14) po završenoj sanaciji napuštenoga radnog prostora potrebno je utvrditi trenutno stanje kvalitete tla na saniranom prostoru, u ovom slučaju benzinske postaje. Metode rada uključena u ova istraživanja imale su uobičajene korake: terenski rad (vertikalno i horizontalno prikupljanje uzoraka tla u porušenom stanju na prostoru benzinske postaje i neposrednom okolišu), laboratorijske analize i obradu podataka prikupljenih u prethodnim stadijima. Prikupljeni uzorci tla su dostavljeni i analizirani u ovlaštenom i akreditiranom laboratoriju za ove poslove. Provedene su uobičajene kemijske analize tla (reakcija i sadržaj organske tvari) te analize na sadržaj organskih i anorganskih onečišćenja tla. Pri pisanju elaborata susreli smo se s narednim problemom. U Republici Hrvatskoj ne postoje granične vrijednosti za vrednovanje stanja kvalitete tehnogenih tala, budući da u RH postoji samo Pravilnik o zaštiti poljoprivrednog zemljišta od onečišćenja štetnim tvarima (NN 9/14). Za razliku od RH, zemlje našeg okruženja su pristupile izradi graničnih vrijednosti koje se odnose na različite načine korištenja zemljišta. Temeljem navedenih Pravilnika o različitom načinu korištenja zemljišta u nama susjednim zemljama još davne 2008. godine izrađen je prijedlog kriterija o različitom korištenju zemljišta u RH. Na žalost, 10 godina poslije ti pravilnici još nisu zaživjeli. Čak što-više, trenutno važeći Pravilnik o zaštiti poljoprivrednog zemljišta ima određene nedostatke u odnosu na stariji Pravilnik iz 1992. godine. Arsen, kobalt i molibden nisu obuhvaćeni navedenim Pravilnikom iz 2014., a nisu ni propisane ikakve vrijednosti za ove metale. Naredni problem su različite granične vrijednosti u navedenim Pravilnicima za neke teške metale. Prema Pravilniku iz 1992. maksimalno prihvatljiv sadržaj iznosio je 300 mg/kg za Zn, 60 mg/kg za Ni i 100 mg/kg za Cr. Prema važećem Pravilniku iz 2014. za Zn sadržaj iznosi 60 mg/kg, 30 mg/kg za Ni i 40 mg/kg za Cr. Sve navedeno upućuje na to da je potrebna hitna usklađenost i nadogradnja zakonske legislative koja se odnosi na granične vrijednosti vezane uz sanaciju onečišćenih tehnogenih tala.

**Ključne riječi:** sanacija tla, načini korištenja tla, granične vrijednosti



## **An overview of limiting values of polluted technosols based on the example of the gas station remediation**

Ivica Kisić<sup>1</sup>, Sanja Mesić<sup>2</sup>, Kristina Marković<sup>2</sup>, Antonija Jonjić<sup>1</sup>

<sup>1</sup>*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia  
(ikisic@agr.hr)*

<sup>2</sup>*INA- Industrija nafte, d.d., Avenija Većeslava Holjevca 10, p.p. 555, 10 020 Zagreb, Croatia*

### **Abstract**

Technosols were mainly formed by the human activity in the city areas due to building, factory, road construction, as well as other objects; transferring and mixing the horizons of the natural soil. That type of soil is also determined in the gas station area. According to the accepted legal regulation (Environmental Protection Act: NN 80/13, 153/13, 78/15 and Mining Act: NN 56/13 i 14/14), after the finished remediation of the abandoned workspace, it is required to determine the current condition of the soil quality in the remediated area, in this case the gas station. Working methods included in this research had the usual steps: field work (vertical and horizontal soil sample collecting in the ruinous condition in the gas station and nearby area), laboratory analysis and data processing collected in the previous stages. Collected soil samples were delivered and analysed in the authorised and accredited laboratory for these kind of actions. Standard soil chemical analyses were conducted (soil reaction and organic matter content) and analyses of the content of organic and inorganic soil pollution. During the writing of this elaborate we came across the following problem. There are no limiting values for the condition evaluation of the technosols quality in the Republic of Croatia, since there is only an Ordinance on the protection of agricultural land against pollution caused by harmful substances (NN 9/14). Unlike the Republic of Croatia, the surrounding countries made a step forward in the determination of limiting values which refer to the different ways of land use. Based on the previously mentioned Ordinances on different land use in surrounding countries in 2008, criteria preposition on different ways of land use in the Republic of Croatia was created. Unfortunately, 10 years later, those Ordinances are still not active. Moreover, currently valid Ordinance on the agricultural land protection has certain drawbacks compared to the older Ordinance from 1992. Arsenic, cobalt and molybdenum are not included in the mentioned Ordinance from 2014, and there are no regulated values for these metals. The following problems refer to the different limiting values in the previously mentioned Ordinances for some heavy metals. According to the Ordinance from 1992, the highest acceptable content for Zn was 300 mg/kg, 60 mg/kg for Ni and 100 mg/kg for Cr. According to the valid Ordinance from 2014, content for Zn is 60 mg/kg, 30 mg/kg for Ni and 40 mg/kg for Cr. All these facts indicate the necessity for the urgent compatibility and the legislation upgrade which refers to the limiting values related to the remediation of the polluted technosols.

**Key words:** soil remediation, ways of land use, limiting values



## **Biblijski nauk u vrednovanju odnosa prema prirodi i gospodarenju tlom**

Đurica Pardon

*Dakovačko-osječka nadbiskupija., Matije Gupca 31, 31424 Punitovci (djurica.pardon@gmail.com)*

### **Sažetak**

Polazna teza je da su judeo-kršćanska vjerovanja oblikovala shvaćanje vrijednosti tla u europskoj kulturi, ekonomiji i politici. U članku se ponajprije razmatra u kojoj je mjeri teološka znanost, utemeljena na interpretaciji biblijskih tekstova, utjecala na neodgovorno ekološko postupanje i degradaciju tla. Kršćanski teolozi u posljednje vrijeme otkrivaju do sada zanemarene poruke biblijske mudrosti i pozitivne stavove prema zemaljskoj stvarnosti, stvorenjima i tlu. Novootkriveni biblijski nauk o zemlji predstavlja se u ovom članku kao kvalitetan temelj moralnih normi na kojima se mogu osnovati pozitivni odnosi prema okolišu i prema tlu kao životvornoj sastavnici postojanja ljudskog roda. S namjerom pojasniti biblijski nauk o tlu u članku se pokazuje da se čitav se biblijski vjernički sustav temelji na tripartitnom odnosu: Bog-čovjek-zemlja (tlo). Na temelju biblijskog nauka o tlu mogu se dati neke etičke odrednice za razvoj suvremene tehnologije obrade tla. Toga nauka valja se pridržavati prilikom osmišljavanja smjernica koje će znanstvena i tehnička dostignuća usmjeriti prema boljitku ljudskog roda i kvalitetnijem odnosu prema tlu te ga usmjeriti na pronalaženje tehnoloških dostignuća u osiguravanju hrane koja neće voditi prema degradaciji i uništenju plodnosti nego voditi prema razvoju kvalitetnijih i održivijih praksi gospodarenja tlom omogućujući ljudskom rodu blagostanje i dobrobit bez štetnog djelovanja na tlo.

**Ključne riječi:** teologija, biblijska teologija, teologija zemlje, etika, tlo



## From the general to the detail soil monitoring of children playgrounds in the City of Ljubljana

Marko Zupan<sup>1</sup>, Zala Strojín Božič<sup>2</sup>, Marija Romić<sup>3</sup>, Helena Grčman<sup>1</sup>

*<sup>1</sup>Biotechnical faculty, Department of Agronomy, University of Ljubljana, Jamnikarjeva 101, Ljubljana, Slovenia ([marko.zupan@bf.uni-lj.si](mailto:marko.zupan@bf.uni-lj.si); [helena.grcman@bf.uni-lj.si](mailto:helena.grcman@bf.uni-lj.si))*

*<sup>2</sup>City of Ljubljana, Mestni trg 1, Ljubljana ([zala.strojin-bozic@ljubljan.si](mailto:zala.strojin-bozic@ljubljan.si))*

*<sup>3</sup>Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia ([mromic@agr.hr](mailto:mromic@agr.hr))*

### Abstract

Soils in urban areas can often be loaded with potential contaminants from industrial and urban sources. Potential pollution mainly occurs in two ways: i) via air due to emissions from factories, energy and heating systems, traffic, etc.; ii) using contaminated soils during construction works. Chemical substances and elements accumulate in soils; however, general soil fertility is usually satisfactory for growing grass. The main pathways of contaminants from soil/ground to children are inhalation of soil dust and/or ingestion of soil particles from the hands or toys. The contaminated soil therefore represents a hidden threat for children's health that can be addressed via systematic monitoring of playgrounds. In 2006 the City of Ljubljana decided to assess the quality of children's playgrounds in all 23 public kindergartens (95 playgrounds). The main objective of the project was to get quantitative data about soil pollution and the information about the maintenance of grass cover on the playgrounds. The first step of the investigation was to obtain information about how and when the playground was built, a detailed overview of playground surface, and taking soil samples. Evaluation of the results was done according to Slovenian legislation – Decree on limit, warning and critical concentration values of dangerous substances in soil (Off.G.RS No.68/96). During the monitoring process, preliminary instructions and general rules were given to the competent staff of the kindergartens and the City of Ljubljana. More detailed instructions about the potential risk and how to avoid soil dusting were handed over to those kindergartens where contaminants exceeded warning value. Even more detailed soil sampling to assess horizontal and vertical extent of pollution was done on the playgrounds where Hg and Pb exceeded critical value. The playgrounds were remediated, with the most contaminated part of the soil being removed. Detailed monitoring of new soil and all other materials was conducted during the restoration process.

**Key words:** soil monitoring, contamination of children's playgrounds, Pb, Hg, PAHs, restoration, guidelines



## Phosphorus Balance in Chernozem According to Crop Production in Eastern Croatia

Aleksandra Perčin, Milan Mesić, Željka Zgorelec, Igor Bogunović, Ivana Šestak

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (apercin@agr.hr, mmesic@agr.hr, zzgorelec@agr.hr, ibogunovic@agr.hr, isestak@agr.hr)*

### Abstract

Phosphorus (P) movement through the lithosphere, hydrosphere and biosphere in agroecosystem is affected by application of P fertilizers and by the removal of P from the soil with the harvest of crops. In order to determine the impact of various amounts of mineral fertilizers on crop yield and P status in Chernozem investigation was conducted in vicinity of Vukovar city in period from 2012 to 2016. The experimental design was a randomized block with ten treatments and four replications. Treatments consisted combination of different amounts of P and K fertilizers from 0 to 200 kg/ha and constant amount of N fertilizer (180 kg/ha). P content was determined in soil at the beginning of investigation and after the harvest of: maize (2013), winter wheat (2014), sugar beet (2015) and maize (2016). P status was detected in grain and stem of maize and wheat, in cob of maize and in root and leaf of sugar beet. Removal of P was calculated by multiplication of P content in each part of plant and corresponding yield. Results revealed that in average 440 kg P<sub>2</sub>O<sub>5</sub>/ha of fertilizers was applied in four years and in average 904.3 kg P<sub>2</sub>O<sub>5</sub>/ha was removed by crops. Results of P balance indicate that lower amount of P should be expected in soil after the four years of crop production but due to the many factors in average at the end of investigation soil contains 245.2 kg/ha more phosphorus than initial soil.

**Key words:** soil, environment, phosphorus, fertilization, crops



## The use of mosses as bioindicators of environmental metal pollution

Sven Bogdan<sup>1</sup>, Lana Filipović<sup>1</sup>, Marija Romić<sup>1</sup>, Snježana Mihaljević<sup>2</sup>, Antun Alegro<sup>3</sup>, Monika Zovko<sup>1</sup>

<sup>1</sup>Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia ([mzovko@agr.hr](mailto:mzovko@agr.hr))

<sup>2</sup>Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia

<sup>3</sup>Faculty of Science, University of Zagreb, Rooseveltov trg 6, 10000 Zagreb, Croatia

### Abstract

Effects of pollutants in the environment may be well estimated by using bioindicators suitable for indicating pollution according to their occurrence, frequency, abundance, vitality and changes in responses under certain environmental conditions. Mosses are commonly used as indicators of heavy metal (HM) pollution because of their specific morphological and physiological properties. The unique positions of Risnjak National Park (RNP) on the geomorphological boundary between the coastal Mediterranean part of Croatia and the continental hinterland have evidently caused a considerable atmospheric fallout impact on their soil cover. The aim of research was to evaluate the atmospheric deposition of the HM (Cd, Cr, Hg, Pb and Zn) by using *Hylocomium splendens* (*HS*) and *Brachythecium rutabulum* (*BR*) species of pleurocarpous mosses, which natively grows in the RNP. Mosses were collected during dry and rainy period in 2016 from 5 sampling sites of RNP. Mosses tissue samples were analyzed for Cd, Cr, Hg, Pb and Zn. Data suggest that mosses are more favorably exposed to the atmospheric deposition of contaminants than the soil surface thus enabling the use of mosses as effective bioindicators of metal atmospheric deposition. Conclusions: *i*) *BR* is possibly more suitable for biomonitoring of atmospheric metal deposits than the *HS*; *ii*) higher concentrations of all investigated metals were measured at almost all research locations in moss *BR* and *iii*) higher concentrations of long-range transported HM (Cd, Pb and Zn), also recorded in *BR*.

**Keywords:** air quality, heavy metals, biomonitoring, Risnjak National Park



## Monitoring and assessment of urban soils' quality: Specific case of the City of Zagreb

Helena Bakić Begić<sup>1</sup>, Ivana Hrga<sup>2</sup>, Mirela Jukić<sup>2</sup>, Adela Krivohlavek<sup>2</sup>, Davor Romić<sup>1</sup>, Marija Romić<sup>1</sup>

<sup>1</sup> *Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska (hbakic@agr.hr)*

<sup>2</sup> *Nastavni Zavod za javno zdravstvo "Dr. Andrija Štampar", Mirogojska cesta 16, Zagreb, Hrvatska*

### Abstract

Quantifying urban soil properties is essential for assessing urban ecosystem services and detecting pollution. Characterizing spatial heterogeneity of urban soils properties and function, which may be changed with land use or urbanization, is crucial for understanding urban ecosystem functions. Therefore, the project Monitoring of urban soils' quality of the City of Zagreb was designed to enable collection and analysis of valid and timely soil quality data as a basis for the establishment of an soil monitoring system. 150 soil samples were collected across the city, according to pre-determined transects. Heterogeneity of main physico - chemical soil properties, trace metals, PAH and PCB were determined by applying statistics and geostatistics. Initially, statistical indicators were compared with threshold values established by the Croatian government regulation as well as with the literature data for soil of Central Croatia, soil worldwide and continental crust. Results showed that concentration of Cr, Ni, Pb, Zn, Hg and PAH deviate from baseline concentrations, while distribution of the trace metal concentrations help to interpret their origin caused by anthropogenic and environmental factors. The statistically justified difference of the indicators between land uses was established only for general indicators (EC and granulometry), and Cu and Hg.

**Key words:** urban ecosystem, monitoring, soil properties, spatial heterogeneity, anthropogenic and environmental factors





## Soil dehydrogenase activity and organic matter as affected by management system

Mia Brkljača<sup>1</sup>, Kristina Kulišić<sup>1</sup>, C. Brannon Andersen<sup>2</sup>

<sup>1</sup>*Department of Ecology, Agronomy and Aquaculture, University of Zadar, Trg kneza Višeslava 9, Zadar, Croatia (mbrkljaca@unizd.hr)*

<sup>2</sup>*Department of Earth and Environmental Sciences, Furman University, Greeville, SC USA (brannon.andersen@furman.edu)*

### Abstract

Tillage and agrochemicals negatively affect soil organic matter (SOM) content and microbial activity. Intense cultivation of the Nadin valley began in the 1950s when land was hydro meliorated. Our objective was to assess stratification of microbial activity and SOM to propose the improvements in soil management. Samples were collected according to randomized stratified design from organic (O) and conventional (C) plowed agricultural soils and from natural grass vegetation soils (G). Dehydrogenases activity (DHA) and soil moisture were analyzed at 6 cm increments and C and N (total, organic and inorganic) were analyzed at 2 cm increments, both to the depth of 18 cm. DHA ( $\text{ng g}^{-1} \text{h}^{-1} \text{TPF}$ ) was higher in G ( $36.8 \pm 5.0$ ) than in C ( $13.8 \pm 1.6$ ) or O ( $7.27 \pm 0.95$ ). DHA decreased with depth from  $21.1 \pm 4.8$  (0-6 cm) to  $16.8 \pm 2.4$  (6-12 cm) to  $7.29 \pm 3.2$  (12-18 cm). Water content (%w/w) was higher in O ( $22.1 \pm 1.3$ ) than in C ( $14.2 \pm 2.2$ ) or G ( $16.8 \pm 1.7$ ). Bulk density decreased from  $1.28 \pm 0.05 \text{ g cm}^{-3}$  the upper part of the valley to  $1.16 \pm 0.03 \text{ g cm}^{-3}$  in the lower part indicating coarser texture in upper parts. Soil composition data showed  $4.5 \pm 0.42\%$  total carbon (organic+carbonate),  $1.6 \pm 0.40\%$  organic carbon, and  $0.14 \pm 0.032\%$  soil nitrogen (organic and inorganic). Soils were carbonate-rich with  $26.0 \pm 2.0\%$   $\text{CaCO}_3$ . C:N ratio was 10.7. Results showed that growing grasses in agricultural soils would increase microbial activity, but might decrease soil water content and increase need for water conservation measures.

**Key words:** C:N, conventional, grass, microbial activity, organic



## Response of dehydrogenase activity to increased soil salinity and cadmium concentration in relation to metal chemical speciation

Lana Filipović<sup>1\*</sup>, Marija Romić<sup>1</sup>, Sanja Sikora<sup>2</sup>, Katarina Huić Babić<sup>3</sup>, Vilim Filipović<sup>1</sup>, Davor Romić<sup>1</sup>

<sup>1</sup>University of Zagreb Faculty of Agriculture, Department of Soil Amelioration, Svetosimunska 25, 10000 Zagreb, Croatia (lfilipovic@agr.hr)

<sup>2</sup>University of Zagreb Faculty of Agriculture, Department of Microbiology, Svetosimunska 25, 10000 Zagreb, Croatia

<sup>3</sup>Genera, Development Department, Biology Division, Svetonedeljska 2, 10436 Rakov Potok, Croatia

### Abstract

Coastal alluvial soils are frequently under saline conditions and, because of the sediment deposition along the river estuaries, may become a sink for spectra of contaminants. Dehydrogenase activity (DHA) responds rapidly even to small changes in soil physico-chemical properties and it is used as an indicator of overall soil microbial activity. Despite the fact that metal species in the soil solution will determine its toxicity in the environment, studies on soil DHA which include metal speciation are scarce. Therefore, the present study aimed to reveal the effects of increased soil (NaCl) salinity and cadmium (Cd) concentration (total and available) on DHA, with a special interest in the effect of major Cd species in the soil solution on DHA. In a greenhouse pot experiment, NaCl salinity (50 and 100 mM) was applied to control soil and soil spiked with Cd (5 and 10 mg kg<sup>-1</sup>). This study confirmed that increased soil salinity, as well as Cd contamination may suppress DHA, but in both cases without the difference between the treatments. Although correlations between DHA and Cd species in the soil solutions were not very strong, data still suggest the possibility that different Cd species in the soil solution may have a different effect on DHA, e.g. that CdCl<sub>n</sub><sup>2-n</sup> complexes may have a higher inhibitory effect on DHA than other Cd species. Also, DHA could possibly increase the proportion of organically complexed Cd by dehydrogenating organic compounds present in the soil solution.

**Key words:** enzyme; toxicity; complexation; mobility; bioavailability



## The effect of the abolition of serfdom on the land degradations in Croatia and Slavonia as a result of unregulated hunting

Alicja Izabela Auriga<sup>1</sup>, Miro Gardaš<sup>2</sup>, Daniel Haman<sup>3</sup>

<sup>1</sup>*Faculty of Environmental Management and Agriculture, West Pomeranian University of Technology, al. Piastów 17, Szczecin, Poland*

<sup>2</sup>*Faculty of Law Osijek, Josip Juraj Strossmayer University of Osijek, Stjepana Radića 13, Osijek, Croatia*

<sup>3</sup>*Faculty of Agrobiotechnical Sciences Osijek, Josip Juraj Strossmayer University of Osijek, Vladimira Preloga 1, Osijek, Croatia (daniel.haman@pfos.hr)*

### Abstract

According to Roman law, hunting is free on your own land. In the 9<sup>th</sup> and 10<sup>th</sup> centuries Franciscan kings (Carolinians) placed their own and others properties under the hunting prohibition and already in the 12<sup>th</sup> century the whole state was the king's hunting ground (from which royal or regal hunting right comes). The king gave this right to nobility or cities. This new right was legally explained by glossators in the 12<sup>th</sup> and 13<sup>th</sup> centuries and they were classified as a small regal rights (*iura regalia minora*). Thus, the right of hunting (*ius venandi*) is in fact one of the regalia, or regal rights, authorizations which in the feudal period represented the expression of the ruler's sovereignty. With the abolition of serfdom and class privileges in Croatia and Slavonia in 1848, equality of all citizens was proclaimed before the law. Consequently, apart from the space that the noblemen retained for themselves as hunting grounds, all residents could freely hunt. But it soon became apparent that this was not a good solution. Peasants deprived of the serf obligations and bans begin to hunt down everything that comes to their hands, seriously threatening the game of wildlife and the biodiversity of the environment. Fields are often neglected, and when they hunt, they often go over crops and destroy or damage them. But the authorities soon intervened in such an almost unlimited freedom and the Croatian-Slavonic Regency issued the *Order concerning the hunting* on 4<sup>th</sup> April 1859. With this new order, special hunting grounds were established outside of those that noblemen retained for themselves. For the first time a tenancy for such hunting grounds is introduced.

**Key words:** Land degradations, Croatia, Slavonia, Abolition of serfdom, Unregulated hunting, 19<sup>th</sup> century



## Utjecaj gnojidbe dušičnim i dušično sumpornim gnojivima na randman i kavalitetu maslinovog ulja

Sanja Biškup<sup>1</sup>, Mirela Žanetić<sup>2</sup>, Ivica Ljubenković<sup>3</sup>, Barbara Soldo<sup>3</sup>, Ivana Mitar<sup>3</sup>

<sup>1</sup>*Petrokemija d.d. Kutina, Aleja Vukovar 4, Kutina, Hrvatska (sanja.biskup@petrokemija.hr)*

<sup>2</sup>*Institut za jadranske kulture i melioracije krša, Put Duilova 11, Split,*

<sup>3</sup>*Sveučilište u Splitu Prirodoslovno matematički fakultet, Ruđera Boškovića 33, Split*

### Sažetak

Fiziološka kloroza maslina uzgajanih na karbonatnim tlima Kaštela vrlo je česta pojava kod sorte oblica. Preliminarna ispitivanja pokazala su 33 -54 % ukupnog kalcij karbonata ( $\text{CaCO}_3$ ) u uzorcima tla, dok je u listu sorte oblica uočena nedovoljna opskrbljenost dušikom, magnezijem, bakrom i cinkom. Cilj postavljenog istraživanja bio je istražiti utjecaj sumpora na randman i kvalitativna svojstva ulja te spriječiti klorozu primjenom tekućih gnojiva Fertine V, Fertine B, Fertine R, Fertine Fe. U svakoj od tri varijante gnojidbe dodano je 120 kg dušika uz folijarnu primjenu Fertinama. U prvoj varijanti dodano je 385+77 kg/ha ASN-a, u drugoj 400 + 200 kg/ha Petrokemijasa (NS 20-24) dok u trećoj 150+108 kg/ha UREA. Određen je randman ulja, indeks zrenja, SMK, peroksidni broj, K 232,  $\Delta K$ , ukupni polifenoli, polifenoli, aroma (ukupni aldehidi, alkoholi, esteri, ukupne organske kiseline), sastav masnih kiselina. Postignuti rezultati gnojidbe dušično sumpornim gnojivima u odnosu na standardnu dušičnu gnojidbu pokazali su veći randman ulja; (ASN 11,4 %, Petrokemijas 10,5 %, UREA 10,8%), veći indeks zrenja (ASN 2,85, Petrokemijas 3,27, UREA 2,61) veći sadržaj ukupnih fenola (ASN 810,90 mg/l, Petrokemijas 480,09 mg/l, UREA 350,70 mg/l), veći sadržaj oleinske kiseline (ASN - 70.01 %, UREA 68,42 %) kao i veći sadržaj hlapivih spojeva aromatskih tvari. Iz navedenog vidljivo je da gnojidba dušično sumpornim gnojivima ima brojne prednosti na karbonatnom tlu u odnosu na zasebna dušična gnojiva.

**Ključne riječi:** gnojidba, sumpor, fenoli, aroma, randman ulja



## Agri-char as a soil amendment

Ivan Niko Botica<sup>1</sup>, Azharul Islam<sup>2</sup>, Marija Romić<sup>1</sup>

<sup>1</sup>*Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska ([mromic@agr.hr](mailto:mromic@agr.hr))*

<sup>2</sup>*Forestry and Wood Technology Discipline, Khulna University, Khulna 9208, Bangladesh*

### Abstract

Use of agri-char has been recognized as a feasible climate change mitigation technology mainly by soil carbon sequestration and added to the pool of soil amendments to combat land degradation. From the agricultural aspects, biochars and hydrochars produced from different feedstocks are considered as a valuable source of nutrients. Hydrochar has been proven to be a less expensive and cheaper product in comparison to biochar, but the process of hydrochar generation is still in an experimental phase and should be certainly tailored in terms of feedstock characteristics and desired quality for specific application. Although a number of benefits of agri-char using as soil amendment have been claimed for specific soils so far, such as improved water and nutrient holding capacity, enhanced adsorption of contaminants, provision of favorable environment for soil biota and carbon sink, diverse aspects of chars on soil remain still somewhat uncertain. The results of recent analysis on agri-char application in farming practice, and various column and field experiments indicate its great potential to managing specific soils purposefully, through considering feedstock characteristics and controlling hydrothermal carbonization process conditions. So, we review here the agri-char production process and conditions related to the feedstock characteristics. The aspects of environmental sustainability of agri-char-based soil amendments have been discussed as well.

**Keywords:** Agri-char, Soil amendment, Feedstock characteristics, Production process



## Utjecaj cestovnog i zračnog prometa na onečišćenje tla i biljnog materijala na širem području Zračne luke Dubrovnik

Lepomir Čoga, Sanja Slunjski, Vesna Jurkić, Ivan Pavlović, Ante Biško, Mihaela Šatvar

*Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska (sslunjski@agr.hr)*

### Sažetak

Istraživanja tla i biljnog materijala provedena 2017. na širem području ZL Dubrovnik imala su za cilj utvrditi utjecaj cestovnog i zračnog prometa na njihovo onečišćenje anorganskim (teški metali) i organskim onečišćujućim tvarima (PAH-ovi i PCB-i). Temeljem dobivenih rezultata utvrđene su značajne razlike u pogledu opterećenosti tla i biljnog materijala anorganskim i organskim onečišćujućim tvarima ovisno o analiziranom parametru, matičnom supstratu, vrsti biljnog materijala i udaljenosti od potencijalnog izvora onečišćenja. Povišene koncentracije Ni i Cr u tlu u svim uzorcima, neovisno o udaljenosti od izvora polucije, ukazuju na njihovo geogeno porijeklo, dok su povećane koncentracije Cu rezultat poljoprivredne djelatnosti (primjena zaštitnih sredstava na bazi bakra). Značajno veće vrijednosti Cd, Zn i Pb utvrđene u neposrednoj blizini državne ceste D8 i uzletno sletne staze u odnosu na uzorke tla uzete izvan zone zahvata ZL Dubrovnik ukazuju na jači utjecaj cestovnog i zračnog prometa na njihovu koncentraciju u tlu. Koncentracije svih teških metala i organskih onečišćujućih tvari kod sve tri kulture značajno su niže od MDK u hrani, propisanih Pravilnikom (NN 16/2005). Nešto veće koncentracije Cd i Pb te količine krizena utvrđene u tlu i lišću analiziranih kultura na lokacijama bližim izvoru polucije, u odnosu na uzorke uzete izvan zahvata ZL Dubrovnik ukazuju na mogući rizik od onečišćenja tla i biljnog materijala štetnim tvarima pod utjecajem cestovnog i zračnog prometa.

**Ključne riječi:** cestovni i zračni promet, teški metali, organske onečišćujuće tvari



## **Influence of road and air traffic on soil and plant contamination in the wider area of Dubrovnik Airport**

Lepomir Čoga, Sanja Slunjski, Vesna Jurkić, Ivan Pavlović, Ante Biško, Mihaela Šatvar

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (sslunjski@agr.hr)*

### **Abstract**

Soil and plant material research was carried out in 2017 on the wider area of Dubrovnik Airport. The aim of the research was to determine influence of road and air traffic on soil and plant material contamination with inorganic (heavy metals) and organic pollutants (PAHs and PCBs). Depending on the parameter analyzed, the substrate, the type of plant material and the distance from the potential source of contamination, significant differences were determined regarding the burden of soil and plant material with inorganic and organic pollutants. Enlarged concentrations of Ni and Cr determined in all soil samples regardless of the distance from the source of contamination indicate their geogenic origin, while the higher concentrations of Cu is result of agricultural activity (application of copper-based plant protection products). Significantly higher values of Cd, Zn and Pb determined near the state road D8 and the airfield in relation to soil samples taken outside the Dubrovnik Airport area indicate a stronger influence of road and air traffic on their concentration in soil. Concentration of all heavy metals and organic pollutants in plant material were significantly lower than maximum allowable concentrations in food prescribed by legislation. Some higher concentrations of Cd, Pb and crysene determined in the soil and leaves of analyzed culture at locations near sources of pollution in relation to the samples taken outside Dubrovnik Airport indicate a potential risk of soil and plant material contamination with harmful substances under the influence of road and air traffic.

**Key words:** road and air traffic, contamination, heavy metals, organic pollutants





## Procjena pogodnosti zemljišta za uzgoj smokve na području Zapadnohercegovačke županije

Antonio Ćorić<sup>1</sup>, Zlatko Čmelik<sup>2</sup>, Paulina Šaravanja<sup>1</sup>, Radica Ćorić<sup>1</sup>, Stjepan Husnjak<sup>2</sup>

<sup>1</sup>*Agronomski i prehrambeno-tehnološki fakultet Sveučilišta u Mostaru, Biskupa Čule bb, Mostar, BiH  
(kontakt antonio.coric@hotmail.com; )*

<sup>2</sup>*Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska*

### Sažetak

Smokva je suptropska voćna vrsta s arealom rasprostranjenosti između 25° i 45° sjeverne i južne geografske širine. Područja s prosječnom godišnjom temperaturom zraka višom od 12° C i nadmorskom visinom do 400 metara su prikladna za rast i razvoj smokve. Odgovaraju joj južni položaji, blagog nagiba s dobrom cirkulacijom zraka. Prikladna tla za uzgoj smokve su: pjeskovito- ilovasta, duboka i dobro drenirana tla. U ovom radu procjena pogodnosti zemljišta za uzgoj smokve na području Zapadnohercegovačke županije izvršena je na temelju FAO kriterija procjene zemljišta (FAO, 1976.), tj. na osnovi značajki dominantnog tipa tla u kartiranoj jedinici te na osnovi vanjskih značajki terena (klima, reljef, stjenovitost i dr.) i zahtjeva smokve k navedenim agroekološkim čimbenicima. Na temelju rezultata procjene pogodnosti zemljišta utvrđene su površine po redovima i klasama pogodnosti i izrađena je karta pogodnosti poljoprivrednog zemljišta za uzgoj smokve na području Zapadnohercegovačke županije u mjerilu 1: 200 000. Istraživanjem je utvrđeno da u ukupnim površinama poljoprivrednog zemljišta, do 800 m n.v., na području Zapadnohercegovačke županije 28691,7 ha ili 53,14% zemljišnih površina je pogodno za uzgoj smokve. Najveću površinu zauzimaju zemljišta P-3 klase pogodnosti (23099,9 ha ili 42,8%), potom umjereno pogodna zemljišta (klasa P-2 3396,9 ha ili 6,3%), a najmanju površinu zauzimaju zemljišta P-1 klase pogodnosti (2194,9 ha ili 4,1%). Privremeno nepogodna zemljišta (N-1 klase) zauzimaju površinu od 4026,9 ha (7,5%), dok trajno nepogodna zemljišta (N-2 klase) zauzimaju 21275,6 ha ili 39,3% od ukupne površine poljoprivrednog zemljišta, do 800 m n.v. Glavna ograničenja za uzgoj smokve na istraživanom području su: klima, potom stjenovitost, kamenitost, nagib terena te dubina tla. Prema postojećem stanju površina pod nasadima smokve, na istraživanom području i podataka o pogodnim i privremeno nepogodnim tlima, može se zaključiti da su mogućnosti klimatsko-zemljišnog kompleksa na području Zapadnohercegovačke županije značajne za uzgoj ove voćne vrste.

**Ključne riječi:** agroekološki čimbenici, klase pogodnosti, smokva



## Evaluation of land suitability for growing fig trees in the West Herzegovina County region

Antonio Ćorić<sup>1</sup>, Zlatko Čmelik<sup>2</sup>, Paulina Šaravanja<sup>1</sup>, Radica Ćorić<sup>1</sup>, Stjepan Husnjak<sup>2</sup>

<sup>1</sup>*Faculty of Agriculture and Food Technology University of Mostar, Biskupa Čule bb, Mostar, BiH  
(contact antonio.coric@hotmail.com; )*

<sup>2</sup>*Faculty of Agriculture University of Zagreb, Svetošimunska 25, Zagreb, Croatia*

### Abstract

Fig is a subtropical fruit species with distribution range between 25° and 45° north and south latitude. Areas with average annual air temperature above 12°C and altitude up to 400 meters are suitable for growth and development of fig trees. It prefers gently sloping south positions, with good air circulation. Soils suitable for cultivation of fig trees are sandy-loamy, deep and well-drained soils. In this paper, evaluation of land suitability for growing figs in the West Herzegovina County region was carried out based on FAO land evaluation criteria (FAO, 1976), or based on characteristics of the dominant soil type in the mapped unit and based on external characteristics of the terrain (climate, relief, rockiness, etc.) and requirements of fig trees for the mentioned agroecological factors. Based on land suitability evaluation results, land areas were determined by suitability orders and classes and a map of suitability of agricultural land for cultivation of figs in the West Herzegovina County region was produced at the scale 1:200 000. In the total areas of agricultural land up to 800 m a.s.l. in the West Herzegovina County, the study established that 28691.7 ha or 53.14% of the land area is suitable for growing figs. The P-3 suitability class land occupies the largest area (23099.9 ha or 42.8%), followed by moderately suitable land (P-2 class, 3396.9 ha or 6.3%), and the P-1 suitability class land occupies the smallest area (2194.9 ha or 4.1%). Temporarily unsuitable land (N-1 class) occupies an area of 4026.9 ha (7.5%), while permanently unsuitable land (N-2 class) occupies 21275.6 ha or 39.3% of the total area of agricultural land up to 800 m a.s.l. The main limitations for cultivation of fig trees in the studied area are: climate, stoniness, rockiness, terrain slope and soil depth. According to the present state of areas under plantations of fig trees in the studied area and the data on suitable and temporarily unsuitable land, it can be concluded that the possibilities of the climatic and soil complex in West Herzegovina County are significant for cultivation of this fruit species.

**Key words:** agroecological factors, suitability classes, fig



## Production of forage maize yield under the zinc foliar fertilization and irrigation system

Adrijana Filipović, Goran Stanić, Nikolina Kajić, Ana Mandić, Višnja Vasilj

*Agronomski i prehrambeno-tehnološki fakultet Sveučilišta u Mostaru, Biskupa Čule bb, 88000 Mostar  
(adrijana.filipovic@ptf.sum.ba)*

### Abstract

Production of the forage maize (*Zea mays* L.) is important due to the high dry matter yield and favorable quality characteristics for optimum animal production. Maize forage yield and quality was influence by many interacting environmental, agricultural and genetic factors. Soil water deficit, drought and unbalanced fertilization program are the main reasons maize grain and forage yields decrease. Among nutrient disorder, zinc was recognizing as one of main limiting factors of maize crop growth and yielding. The objective of this study was to evaluate the effects of zinc foliar fertilizer and drip irrigation system on some qualitative and quantitative parameters of forage maize. In this trial, the basic fertilization NPK program was provided on soil analysis basis and additional the foliar treatments of Zn were applied at the 5<sup>th</sup> leaf stage. Trial was set up in complete randomized design in three replications. The zinc foliar treatment whit or without irrigation system have shown up to 18% higher yield compared to the control treatment. Other parameters as hectoliter mass, grain content of nitrogen, phosphorus, potassium and zinc have shown higher recorded values in treatment with included foliar zinc fertilization and irrigation system. The foliar zinc application have shown positive effect on measured parameters along with drip irrigations system however, it is necessary to establish the economic justification for introducing an irrigation system in the production of forage maize.

**Key words:** forage maize, zinc foliar fertilization, drip irrigation system, yield, yielding components



## Trace metals mobility in vineyard soils estimated through soil column experiments and a lysimeter study

Lana Filipović, Davor Romić, Vilim Filipović, Marina Bubalo Kovačić, Monika Zovko, Filip Kranjčec, Gabrijel Ondrašek

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (lfilipovic@agr.hr)*

### Abstract

Various agrochemicals are commonly used in vineyard production and even if metals are not their active component, trace amounts still may be present in their composition. However, copper (Cu) is the main active ingredient in a range of chemicals frequently used in vineyards and Cu concentrations in the topsoil may progressively increase. Thus, estimation of Cu mobility in soils may prove as an important component of monitoring vineyard soils quality. Field trials are conducted on two locations: (i) on the flat coastal terrain (Baštica) and (ii), on a hillslope terrain of the Croatian continental part (Jazbina). Lysimeters were installed at both field sites and undisturbed soil columns taken for the assessment of Cu downward mobility through the soil profile by applying irrigation and a known metal concentration. Initial Cu concentrations were determined in soil samples from both sites. Water samples from lysimeters and leachate from soil columns were taken periodically and analyzed for Cu concentrations; with the distribution of major Cu species estimated using chemical equilibrium software. Results indicate that the sorption and complexation processes with soil organic matter may be the major factor controlling Cu mobility in vineyard soils. Still, the possibility of Cu transfer in a form of complexes with organic ligands (e.g. dissolved organic carbon) through the soil profile by soil water preferential flow pathways and/or through surface runoff will be further studied.

**Key words:** agricultural soil, soil and water quality, chemical speciation, metal transfer



## Element phytoavailability in soils of a long-term field experiment amended with urban waste composts

Lana Filipović<sup>1</sup>, Aurélie Michaud<sup>2</sup>, Philippe Cambier<sup>2</sup>, Vilim Filipović<sup>1</sup>, Pierre Benoit<sup>2</sup>, Sabine Houot<sup>2</sup>

<sup>1</sup>*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (lfilipovic@agr.hr)*

<sup>2</sup>*UMR ECOSYS, INRA, AgroParisTech, Univ. Paris-Saclay, 78000 Versailles, France*

### Abstract

The use of organic waste products (OWP) on agricultural soils may have numerous benefits, but certain concerns regarding nutrient fluxes (N, P) or increased inputs of toxic elements (Cd) are also present. Previous research showed that compost amendments may affect more the available than the total element concentration in the soil, thus the aim of study was to evaluate the effects of a long-term urban waste composts application started in 1998 on soil element availability to plants. Element composition of wheat and maize (straw and grain) grown on four experimental plots amended with 3 composts (sewage sludge with green waste and wood chips - SGW, fermentable organic waste with green waste - BIO, municipal waste after selective sorting - MSW) and a farmyard manure - FYM, were compared to the element composition of plants grown on a control plot receiving only nitrogen mineral fertilizer (CTR), for the period 2008-2013. Significantly lower N, P, K and S concentrations and higher Cd and Mn concentrations were periodically recorded in straw and/or grain of wheat grown in CTR plot compared to wheat grown in OWP amended plots. Lower Mo concentration was repeatedly recorded in maize grown in CTR plot (straw and grain). Data suggest that the OWP application may affect certain major and/or trace element soil availability to plants, but their phytoavailability also showed differences between the years and/or cultivated crop.

**Key words:** organic amendment, element cycling, soil quality, trace metal



## Estimation of vineyard pesticides mobility through soil column experiments and lysimeters study

Vilim Filipović<sup>1</sup>, Sanja Stipičević<sup>2</sup>, Sanja Fingler<sup>2</sup>, Lana Filipović<sup>1</sup>, Marina Bubalo Kovačić<sup>1</sup>, Filip Kranjčec<sup>1</sup>, Klara Barić<sup>1</sup>, Gabrijel Ondrašek<sup>1</sup>

<sup>1</sup>Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (vfilipovic@agr.hr)

<sup>2</sup>Institute for Medical Research and Occupational Health, Ksaverska cest 2, Zagreb, Croatia

### Abstract

Extensive use of pesticides in a conventional agriculture although necessary to improve crop production, may at the same time pose a threat to soil and water quality. Two main active substances were in focus of this research: glyphosate (broad-spectrum, post emergence, non-selective herbicide) and cypermethrin (synthetic pyrethroid insecticide), both commonly used in vineyards. Two locations were selected for the field trial: Baštica located on the flat coastal terrain, and Jazbina located on a hillslope terrain characteristic for vineyard production in the continental part of Croatia. At both field sites, zero tension lysimeters were installed and water balance components monitored throughout the year. Undisturbed soil columns were taken from both sites and used to estimate mobility of pesticides by applying irrigation and a known dosage of both pesticides (optimum field quantity) in a controlled environment. Water samples from lysimeters and leachate from soil columns were taken periodically and analyzed for active substances. In addition, soil samples were taken, and initial pesticides concentrations were measured, as well as the soil sorption capacity at each site. First results indicate that the sorption coefficient ( $K_d$ ) was the main process limiting pesticide mobility in soil. Both pesticides have high capacity to be adsorbed by the soil particles and organic matter present in the soil surface layer. Thus, the possible losses of pesticides through surface runoff (e.g. colloidal transport) or by soil water preferential flow pathways will be further studied.

**Key words:** pesticide fate, glyphosate, cypermethrin, agricultural soil, soil and water quality



## Modeling soil mobility of Cu and Cd originating from urban waste compost using HYDRUS-2D

Vilim Filipović<sup>1</sup>, Philippe Cambier<sup>2</sup>, Lana Filipović<sup>1</sup>, Yves Coquet<sup>3</sup>, Valérie Pot<sup>2</sup>, Guillaume Bodineau<sup>2</sup>, Anne Jaulin<sup>2</sup>, Vincent Mercier<sup>2</sup>, Sabine Houot<sup>2</sup>, Pierre Benoit<sup>2</sup>

<sup>1</sup>Department of Soil Amelioration, Faculty of Agriculture, University of Zagreb, Svetošimunska 25, 10000 Zagreb, Croatia

<sup>2</sup>UMR ECOSYS, INRA, AgroParisTech, Univ. Paris-Saclay, 78000 Versailles, France

<sup>3</sup>ISTO Univ. d'Orléans, CNRS-INSU, BRGM, 45071 Orléans, France

### Abstract

Urban waste composts may contain trace metals and the estimation of their mobility in soils after the compost application is an important approach for monitoring the quality of the amended soils. Thus, the objective was to simulate Cu and Cd leaching from the compost amended soils by using HYDRUS-2D numerical modeling. Two experimental plots amended with a co-compost of sewage sludge and green wastes (SGW) or with a municipal solid waste compost (MSW) were compared to a control plot (CONT). Two sorption estimation approaches were used: either assuming the equilibrium between  $\text{CaCl}_2$  and EDTA extractable metals ( $K_{d-1}$ ), or using the equations based on pedotransfer functions assuming nonlinear sorption for Cu ( $K_f$ ) and a linear sorption for Cd ( $K_{d-2}$ ). Cu lysimeter data were successfully reproduced with the  $K_{d-1}$  approach for the SGW and CONT plots (model efficiency coefficient  $E_{\text{SGW}}=0.97$ ,  $E_{\text{CONT}}=0.95$ ), while the MSW plot showed better fitting with the  $K_f$  approach ( $E_{\text{MSW}}=0.77$ ), possibly because of the less stable organic matter in the MSW compost. The Cd leaching was reproduced with the  $K_{d-2}$  approach for the two amended plots ( $E_{\text{SGW}}=0.12$ ,  $E_{\text{MSW}}=0.80$ ), while the CONT plot fluxes were poorly simulated ( $E_{\text{CONT}}=-29.52$ ), probably due to the overestimation of the low pH and organic carbon effect on  $K_{d-2}(\text{Cd})$ . The mobility of both, Cu and Cd appeared to be quite low in the tilled layer, suggesting that the organic matter and added compost sorption capacity had a major role for their soil mobility.

**Keywords:** soil quality, compost amendments, trace metals leaching, numerical simulations





## Spatial variability of soil magnetic susceptibility across Croatia

Ozren Hasan<sup>1</sup>, Slobodan Miko<sup>1</sup>, Nikolina Ilijanić<sup>1</sup>, Ivona Ivkić<sup>2</sup>, Andreja Steinberger<sup>3</sup>, Hrvoje Marjanović<sup>4</sup>, Branka Grahovac<sup>5</sup>

<sup>1</sup>Croatian geological survey, Sachsova 2, Zagreb, Croatia (ohasan@hgi-cgs.hr)

<sup>2</sup>Gračanska cesta 15, Zagreb

<sup>3</sup>Hrvatska agencija za okoliš i prirodu, Radnička cesta 80/7, 10 000 Zagreb

<sup>4</sup>Hrvatski šumarski institut, Zavod za uređivanje šuma i šumarsku ekonomiku, Trnjanska cesta 35, 10000 Zagreb

<sup>5</sup>Hrvatski centar za poljoprivredu, hranu i selo, Odjel za praćenje stanja poljoprivrednog zemljišta Vinkovačka cesta 63c, 31 000 Osijek

### Abstract

Magnetic susceptibility (MS) of soils and paleosols indicates the formation of secondary ferrimagnetic minerals (SFM) and pedogenic processes. Comprehensive analysis of surface (0-10 cm depth) and sub-surface soils (20-30 cm depths) from over 750 locations in Croatia have been performed through measurements of low field mass specific MS (Xlf) and mass specific and percentage of frequency-dependent MS (Xfd) to determine spatial distribution of MS that can be used for provenance studies of soil, erosional processes as well as evaluation of soil pollution by heavy metals. It is also needed for the landmine-affected regions because it of the effects of soil magnetic susceptibility on metal detectors. Maps of soil MS in Croatia show two clearly differentiated distributions – Pannonian region versus karst area of Croatia. Differences are linked to geological sub-division of Croatia and its associated main soil types: the Mesozoic carbonate rocks of the Dinaric-Coastal karstic region with dominant red soils and kalkocambisols versus Pannonian region with dominant cambic, eluvial illuvial and gleyic soils mostly developed on clastic Neogene and Quaternary sediments. Soils developed on carbonate rocks have higher values of MS and Xfd compared to soils of Pannonian region. Magnetic properties of soils in karstic area are dominated by the presence of nanoscale superparamagnetic (SP) SFM grains produced in situ. Soil-derived magnetite gives major contribution to the magnetic enhancement in red soils. Primary ferrimagnetic minerals derived from geological sources dominate magnetic properties in only a minority of localities (mountainous areas composed of magmatic and metamorphic rocks). This is the first attempt to produce a soil magnetic susceptibility map Croatia that covers all dominant soil types in Croatia.

**Key words:** Magnetic susceptibility, Croatian soils, ferromagnetic minerals, karst, pedogenesis



## Potential of Sewage Sludge Application in the Mediterranean Agricultural soils: Case of Šibenik region, Croatia

Vito Horvatić, Davor Romić, Helena Bakić Begić, Monika Zovko, Marija Romić

*University of Zagreb Faculty of Agriculture, Department of Soil Amelioration, Svetošimunska 25, 10000 Zagreb*

### Abstract

Rural areas in Croatia have great potential in the shape of natural assets and landscapes, which is an excellent basis for the economic development, considering two main economic branches: agriculture and tourism. In the context of integrated land and water management, production of wastewater effluent and large quantities of sewage sludge from the local sewage treatment plants may be an issue of high significance. Submerged wastewater effluent discharge in the vicinity of cities along the Adriatic Sea coast may lead to coastal marine sediment contamination by inorganic and organic pollutants, depending of sewage treatment system performance. The city of Šibenik area (Middle Eastern Adriatic coast) had faced in the past the serious problem of the eutrophication of the Krka River Estuary and coastal marine environment that had been receiving untreated industrial and domestic sewage for years. As a region is very attractive because of natural beauties, the problem was becoming more pronounced during the touristic summer period. Sewage treatment system and pipe line to outside of Krka River Estuary was constructed in 2008, and treated effluent is being released into the near shore marine environment SE of the Island of Zlarin by 5000 m long sub-marine pipe system. The investigation undertaken to examine the metal concentrations in marine sediments influenced by the wastewater disposal system showed no distinct anthropogenic loads of trace elements in sediment that may be related to the wastewater effluent discharge. Anyway, quantities of the sewage sludge that remain after the treatments may pose great risk for environment if not treated, stored or disposed properly. It was estimated that 1.846 tones (dry mater) is being produced monthly from sewage tratment plants in 5 agglomeration of the Sibensko-kninska County (SKC). Application of treated sludge to agricultural land was considered to be the best practicle environmental option for most sewage sludge, but this option has to be carefully examined. In the last two decades more than 5000 ha of karst stony terraces and steep slopes in the study region have been remediate by stone crushing to make the land suitable for agricultural production, mostly for grapevine and olive production. After the deforestation, new grapevine and olive trees plantations are made particularly on the slopes exposed to sun and sheltered from strong winds. So, the capacity of the arable land to take on sewage sludge from the local treatment plants in SKC has been defined by this study.

**Key words:** sewage sludge, Mediterranean Agricultural soils



## Utjecaj kalcizacije na sadržaj humusa u tlu

Vladimir Ivezić, Katarina Perić, Meri Engler, Brigita Popović, Zdenko Lončarić, Krunoslav Karalić

*Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira Preloga 1, Osijek, Hrvatska (vivezic@pfos.hr)*

### Sažetak

Kalcizacija tj. neutralizacija kiselih tala u poljoprivredi se vrši primjenom materijala bogatih Ca i Mg koji imaju sposobnost podizanja pH vrijednosti tla. Sve je češća primjena nusproizvoda iz industrijske proizvodnje kao kalcizacijskih sredstava. Naglo podizanje pH vrijednosti tla često može imati negativan utjecaj na humus u tlu, tj. podizanjem pH vrijednosti tla potiče se mikrobiološka aktivnost a time i brža razgradnja humusa. Cilj istraživanja je utvrditi mogućnost primjene tri nova kalcizacijska materijala (drveni pepeo, filtarska prašina i bazična troska) te karbokalka kao kalcizacijskog sredstva dostupnog na tržištu te istražiti njihov kalcizacijski učinak ali i utjecaj na sadržaj humusa u tlu. Istraživanje je provedeno tijekom 2015. - 2017. na dva lokaliteta u blizini Feričanaca. Na temelju dvogodišnjeg pokusa s lucernom, kroz četiri otkosa, utvrđeno je da su pepeo i filtarska prašina jednako uspješni u neutralizaciji suviše kiselosti kao i karbokalk, dok je bazična troska podigla pH vrijednosti u odnosu na kontrolu, no statistički slabije nego ostala tri kalcizacijska sredstva. Sadržaj humusa se nije bitno mijenjao tijekom prva tri otkosa no u četvrtom otkosu je primijećeno opadanje humusa na parcelama gdje je korišten karbokalk, pepeo i bazična troska dok kod kontrole i primjene filtarske prašine nije primijećeno statistički značajno opadanje humusa. Dakle, od istraživanih materijala, filtarska prašina se pokazala kao najbolje sredstvo i sa stajališta očuvanja plodnosti tla.

**Ključne riječi:** bazična troska, filtarska prašina, karbokalk, pepeo



## Utjecaj dušičnog stresa na neka svojstva pšenice u ovisnosti o sorti i okolini

Marko Ivić<sup>1</sup>, Ivana Plavšin<sup>1</sup>, Marko Černe<sup>2</sup>, Brigita Popović<sup>3</sup>, Marko Maričević<sup>4</sup>, Ana Lovrić<sup>5</sup>, Hrvoje Šarčević<sup>5</sup>, Dario Novoselović<sup>1</sup>

<sup>1</sup>Poljoprivredni institut Osijek, Južno predgrađe 17, Osijek,, Hrvatska ([marko.ivic@poljinos.hr](mailto:marko.ivic@poljinos.hr))

<sup>2</sup>Institut za poljoprivredu i turizam Poreč, Karla Huguesa 8, Poreč, Hrvatska

<sup>3</sup>Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira Preloga 1, Osijek, Hrvatska

<sup>4</sup>BC Institut d.d., Dugoselska 7, Dugo Selo, Hrvatska

<sup>5</sup>Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska cesta 25, Zagreb, Hrvatska

### Sažetak

Dušik kao makroelement utječe na cjelokupan razvoj biljke pšenice. Cilj rada je da se, na osnovi jednogodišnjeg mikropokusa (64 sorte ozime pšenice, lokacije Osijek i Poreč, N tretman: N bez prihrane i 100 kg N ha<sup>-1</sup>), utvrdi utjecaj dušika na analizirana svojstva, značajnost samih tretmana i njihovih interakcija (gnojidba, lokacija i N tretman) te koreliranost između agronomski značajnih svojstava i NDVI indeksa u busanju, vlatanju i klasanju sa sadržajem dušika u cvatnji. Analiza varijance utvrdila je značajnost razlika između svih tretmana za sva svojstva, te značajnost interakcija lokacija\*N tretman za visinu biljke i sadržaj proteina, genotip\*lokacija za urod i sadržaj proteina zrna, te interakciju genotip\*lokacija\*N tretman za urod zrna. Negativna koreliranost najčešće je utvrđena između uroda zrna s sadržajem proteina u zrnu ( $r=-0.57^{***}$ ) i visinom ( $r=-0.41^{**}$ ), sadržaja dušika u cvatnji s NDVI indeksom u busanju, vlatanju i klasanju ( $r=-0.27^*$ ,  $r=-0.47^{***}$ ;  $r=-0.26^*$  i  $r=-0.42^{***}$ ;  $r=-0.30^*$ ), ovisno o lokaciji i N tretmanu. Pozitivna koreliranost utvrđena je između hektolitarske mase s visinom ( $r=0.26^*$ ) i sadržajem proteina u zrnu ( $r=0.62^{***}$ ;  $r=0.55^{***}$ ;  $r=0.40^{***}$ ), te visine i sadržaja proteina ( $r=0.27^*$ ), ovisno o o lokaciji i N tretmanu. Dobiveni rezultati utvrdili su značajan utjecaj svih tretmana i njihovih interakcija na analizirana svojstva kao i ograničenu primjenu mjerenja NDVI indeksa u procjeni opskrbljenosti biljke dušikom.

**Ključne riječi:** pšenica, dušik, gnojidba, urod zrna, NDVI



## Režim vlažnosti tla u uvjetima uzgoja trešnje i kruške

Toni Jagečić, Stjepan Husnjak, Danijela Jungić

*Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska (shusnjak@agr.hr)*

### Sažetak

Ciljevi ovog rada su utvrditi režim vlažnosti tla u uvjetima uzgoja trešnje i kruške, kao i značajnost utjecaja pojedine voćne vrste na režim vlažnosti. Istraživanje je provedeno tijekom 2016. na dobru Agronomskog fakulteta u Zagrebu, tijekom vegetacije navedenih voćnih vrsta (IV-IX). Uzorkovanje tla za određivanje trenutačne vlažnosti obavljeno je dekadno, u 3 ponavljanja, sa dvije dubine (0-20 cm i 20-40 cm). U laboratoriju je vlažnost tla određena gravimetrijski. Minimalna vrijednost vlage tla na dubini tla 0-20 cm pod trešnjom je iznosila 24,1 % vol., a maksimalna 40,8% vol., dok je na dubini 20-40 cm najmanje vlage bilo 24,6% vol., a najviše 37,8% vol. U tlu pod kruškom na dubini 0-20 cm količina vlage se kretala u rasponu od 16,0 do 34,7% vol. Na dubini tla 20-40 cm najmanje vlage bilo je 14,9% vol., a najviše 32,7% vol. Tijekom cijele vegetacije trešnje, na obje dubine tla, vrijednosti trenutačne vlage bile su između vrijednosti kapaciteta tla za vodu (44,6% vol) i točke venuća (20,7% vol.), dok je vlažnost tla u vegetaciji kruške bila povremeno ispod točke venuća od srpnja do rujna. U obje dubine tla pod trešnjom dobivene su statistički značajno veće količine vlage u tlu u odnosu na tlo pod kruškom. Izračunom bilance oborinske vode u tlu, u razdoblju srpanj-rujan manjak vode u tlu pod trešnjom iznosio je 79,0 mm, a pod kruškom 104,2 mm. Dobiveni izračun je u skladu sa rezultatima vlage dobivenim gravimetrijskom metodom u laboratoriju. Rezultati ukazuju na potrebu daljnjih istraživanja, kao i višegodišnjeg praćenja klimatskih značajki i režima vlažnosti tla u uzgoju voćnih vrsta.

**Ključne riječi:** režim vlažnosti tla, bilanca oborinske vode, trešnja, kruška



## Soil Moisture Regime in Cherry and Pear Cultivation

Toni Jagečić, Stjepan Husnjak, Danijela Jungić

*Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska (shusnjak@agr.hr)*

### Abstract

This paper's goals are to determine the soil moisture regime in cherry and pear cultivation, and to determine how significant would the influence of a particular fruit be on the soil moisture regime. The research was conducted in 2016 in the area of the Faculty of Agriculture at the University of Zagreb during the vegetation of the aforementioned fruit (IV-IX). The samplings for determining the current moisture content in the soil were conducted in three stages and in two depths (0-20 cm and 20-40 cm). Moisture content was determined in a laboratory, using a gravimetric method. Minimum moisture content in the soil 0-20 cm under the cherry tree amounted to 24.1 percent vol., and maximum 40.8 percent vol., while at the depth of 20-40 cm the lowest moisture percentage amounted to 24.6 percent vol., and the highest 37.8 percent vol. In the soil under the cherry tree, at 0-20 cm, the amount of moisture varied between 16.0 and 34.7 percent vol. At 20-40 cm the lowest moisture percentage amounted to 14.9 percent vol., and the highest 32.7 percent vol. During cherry vegetation, in both soil depths, the value of current moisture in the soil ranged between soil water capacity (44.6 percent vol.) and the wilting point (20.7 percent vol.), while the soil moisture in pear vegetation occasionally reached below the wilting point (VII - IX). Statistically higher amount of soil moisture was found in both depths under the cherry tree than under the pear tree. The calculation of the soil water balance has confirmed the deficiency of soil water in cherry trees in July, August and September in the amount of 79.0 mm, while the deficiency of soil water in pear trees amounted to 104.2 mm. The given calculations coincide with the results gained by gravimetric method in the laboratory. The results show that there is a need for further research, as well as long-term need for the analysis of climatic features and soil moisture regime in fruit cultivation.

**Key words:** soil moisture regime, soil rainwater balance, cherry tree, pear tree



## Impact of arbuscular mycorrhizal fungi application on processing tomato fruit quality and mineral content

Jana Klanjac<sup>1</sup>, Tomislav Radić<sup>2</sup>, Smiljana Goreta Ban<sup>1</sup>, Igor Palčić<sup>1</sup>, Marina Lukić<sup>1</sup>, Mia Brkljača<sup>3</sup>, Paula Žurga<sup>4</sup>, Dean Ban<sup>1</sup>, Zdravko Matotan<sup>5</sup>, Branimir Urlić<sup>2</sup>, Katarina Hančević<sup>2</sup>, Igor Pasković<sup>1\*</sup>

<sup>1</sup>*Institute of Agriculture and Tourism, K. Huguesa 8, 52440 Poreč, \*(paskovic@iptpo.hr)*

<sup>2</sup>*Institute for Adriatic Crops and Karst Reclamation, Put Duilova 11, 21000 Split, Croatia*

<sup>3</sup>*Department of Ecology, Agronomy and Aquaculture, University of Zadar, Trg kneza Višeslava 9, 23000 Zadar, Croatia*

<sup>4</sup>*Teaching Institute of Public Health Primorsko-goranska County, Krešimirova 52a, 51000 Rijeka, Hrvatska*

<sup>5</sup>*Podravka d.d., Ante Starčevića 32, 48000 Koprivnica, Croatia*

### Abstract

Croatian largest fields of processing tomato are found in the part of Istria with red type of soil ‘Terra rossa’. Natural characteristics of the red soil are associated with low organic matter and insufficient amount of plant available phosphorus, which is an essential plant nutrient for vegetable yield and its quality as well. In such conditions, frequent and excessive use of mineral fertilizers with a negative impact on the environment can be noticed. Processing tomato has a high affinity for the symbiosis with arbuscular mycorrhizal fungi (AMF). Therefore, mycorrhiza application may represent an innovative and sustainable solution to increase processing tomato productivity. The objective of this study was to determine the effect of AMF (*Glomus intraradices* and *Glomus mosseae*) application on processing tomato yield, fruit quality and mineral content under standard fertilization management practice. Seedlings inoculated with AMF (M) increased phosphorous, arsenic and vanadium concentrations and decreased lead concentration in tomato fruits compared to uninoculated control (K). The concentrations of all selected nutrients were significantly below the maximum permitted concentrations for human consumption. At the harvest, roots of control plants were also colonized by naturally present AMF in the soil but with significantly lower extent when compared to inoculated plants. No significant differences were detected between treatments in yield and fruit quality parameters.

**Keywords:** *Solanum lycopersicum* L., Terra rossa, phosphorus, *Glomus intraradices*, *Glomus mosseae*





## Utjecaj primjene arbuskularnih mikoriznih gljiva na kvalitetu i mineralni sastav ploda industrijske rajčice

Jana Klanjac<sup>1</sup>, Tomislav Radić<sup>2</sup>, Smiljana Goreta Ban<sup>1</sup>, Igor Palčić<sup>1</sup>, Marina Lukić<sup>1</sup>, Mia Brkljača<sup>3</sup>, Paula Žurga<sup>4</sup>, Dean Ban<sup>1</sup>, Zdravko Matotan<sup>5</sup>, Branimir Urličić<sup>2</sup>, Katarina Hančević<sup>2</sup>, Igor Pasković<sup>1</sup>

<sup>1</sup>Institut za poljoprivredu i turizam, K. Huguesa 8, 52440 Poreč, Hrvatska \*(paskovic@iptpo.hr)

<sup>2</sup>Institut za jadranske kulture i melioraciju krša, Put Duilova 11, 21000 Split, Hrvatska

<sup>3</sup>Odjel za ekologiju, agronomiju i akvakulturu, Sveučilište u Zadru, Trg kneza Višeslava 9, 23000 Zadar, Hrvatska

<sup>4</sup>Nastavni zavod za javno zdravstvo Primorsko-goranske županije, Krešimirova 52a, 51000 Rijeka, Hrvatska

<sup>5</sup>Podravka d.d., Ante Starčevića 32, 48000 Koprivnica, Hrvatska

### Sažetak

Proizvodnja industrijske rajčice u Hrvatskoj prevladava u Istri na crvenici 'Terra rossa' koju karakterizira prirodno niska razina organske tvari i nedovoljna količina biološki dostupnog fosfora. Fosfor je neophodan element za postizanje optimalnih prinosa i kvalitetu plodovitog povrća. Stoga u proizvodnim uvjetima često prevladava prekomjerna mineralna gnojidba koja može imati nepovoljan utjecaj na okoliš. Industrijska rajčica posjeduje visok afinitet prema simbiozi s arbuskularnim mikoriznim gljivama (AMG) pa one predstavljaju jedno od inovativnih i ekološki prihvatljivih rješenja za povećanje produktivnosti industrijske rajčice na crvenici. Cilj ovog rada bio je istražiti utjecaj primjene AMG (*Glomus intraradices* i *Glomus mosseae*) na prinos, kvalitetu i mineralni sastav ploda industrijske rajčice u proizvodnim uvjetima. Presadnice industrijske rajčice inokulirane s AMG (M) pokazale su veću koncentraciju fosfora, arsena i vanadija te manju koncentraciju olova u plodu u odnosu na presadnice koje nisu bile inokulirane s AMG-kontrola (K). Koncentracije navedenih elemenata bile su značajno ispod maksimalno dozvoljenih koncentracija za ljudsku prehranu. Prilikom berbe, K biljke pokazale su veliki stupanj mikoriziranosti korijena prirodno prisutnim AMG u tlu, no u odnosu na M biljke stupanj mikoriziranosti bio je značajno manji. Između tretmana nije bilo značajnih razlika u prinosu i kvaliteti ploda rajčice.

**Ključne riječi:** *Solanum lycopersicum* L., Terra rossa, fosfor, *Glomus intraradices*, *Glomus mosseae*



## Agronomska biofortifikacija soje na tlu siromašnom selenom

Zdenko Lončarić<sup>1</sup>, Mirjana Martić<sup>2</sup>, Domagoj Rastija<sup>1</sup>, Darko Kerovec<sup>1</sup>, Aleksandra Sudarić<sup>3</sup>

<sup>1</sup> *Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira Preloga 1, Osijek, Hrvatska*

<sup>2</sup> *Srednja škola Matije Antuna Reljkovića, Ivana Cankara 76, Slavonski Brod*

<sup>3</sup> *Poljoprivredni institut Osijek, Južno predgrađe 17, Osijek*

### Sažetak

Pothranjenost ljudi selenom posljedica je niskih koncentracija Se u tlima te posljedično u hrani. Učinkovita su rješenja genetska i agronomska biofortifikacija te je s ciljem utvrđivanja učinkovitosti i sorte specifičnosti provedena agronomska biofortifikacija 5 sorata soje na tlu siromašnom selenom. Na slabokiselom tlu siromašnom fosforom i dobro opskrbljenom kalijem utvrđene su srednje razine ukupnih koncentracija esencijalnih i niske koncentracije štetnih teških metala i ukupnog Se (294-342  $\mu\text{g Se kg}^{-1}$ ). Agronomska biofortifikacija soje provedena je folijarnom aplikacijom otopine  $\text{Na}_2\text{SeO}_4$  u fenofazi cvatnje u količini 10 g Se  $\text{ha}^{-1}$ . Folijarna aplikacija selena nije utjecala na prinos zrna soje, ali je povećala koncentraciju Se u zrnu prosječno 19,7 puta. Naime, u kontrolnom je tretmanu utvrđena koncentracija 30  $\mu\text{g Se kg}^{-1}$ , a nakon folijarne aplikacije 588  $\mu\text{g Se kg}^{-1}$ . Utvrđene su i sorte specifičnosti jer je najveća koncentracija selena utvrđena u biofortificiranom zrnu sorte Sanda (780), zatima Ika (660), Lucija (596), Korana (556), a najmanja u zrnu sorte Toma (351  $\mu\text{g Se kg}^{-1}$ ). Utvrđeno je povećanje koncentracije Se i u mahunama (210  $\mu\text{g Se kg}^{-1}$ ) u odnosu na kontrolni tretman (17  $\mu\text{g Se kg}^{-1}$ ) uz razlike između sorata. Rezultati su pokazali uspješnost i sortnu specifičnost agronomske biofortifikacije soje s prosječnim povećanjem koncentracije Se u zrnu 19,7 puta u odnosu na kontrolu do najvećih 780  $\mu\text{g Se kg}^{-1}$ .

**Ključne riječi:** soja, sortna specifičnost, biofortifikacija, folijarna aplikacija



## Usporedba temperaturnog režima tla u voćnjacima jabuke i trešnje

Ivan Magdić, Stjepan Husnjak, Danijela Jungić, Toni Jagečić

*Agronomski fakultet, Sveučilište u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska  
(e-mail: [imagdic@agr.hr](mailto:imagdic@agr.hr))*

### Sažetak

Temperatura tla utječe na fizikalne, kemijske i biološke procese u tlu te fiziološke procese u biljci. Temperaturni režim tla predstavlja promjene temperature u tlu tijekom određenog vremenskog razdoblja. Cilj istraživanja bio je utvrditi postoje li razlike u temperaturnom režimu tla između voćnjaka jabuke i trešnje kroz vegetacijsko razdoblje (04. – 09. mjesec) tijekom 2016. godine. Spomenute voćne vrste nalaze se u istom voćnjaku u sklopu Agronomskog fakulteta Sveučilišta u Zagrebu (45°49'43"S, 16°01'44"E). Temperatura tla mjerena je termometrima postavljenima na dvije dubine (20 i 40 cm) na udaljenosti 30 cm od debla voćke. Temperatura tla očitavana je svakih 5 dana. Tlo na kojem se provodilo istraživanje prema sistematskoj oznaci pripada redu terestričkih tala, tipu rigolano te podtipu iz eutrično smeđeg. Statistička obrada podataka odrađena je t-testom za zavisne uzorke u statističkom paketu SAS Enterprise Guide 6.1. Temperatura tla na 20 cm dubine kretala se između minimalnih (MIN) 11,8 °C (20. 04.) do maksimalnih (MAX) 25,3 °C (08. 08.) kod jabuke, odnosno MIN 11,8 °C (20. 04.) do MAX 25 °C (08. 08.) kod trešnje. Na dubini od 40 cm temperatura tla se kretala od MIN 10,9 °C (04. 04.) do MAX 24,1°C (25. 07.) kod jabuke, odnosno od MIN 10,9 °C (04. 04.) do MAX 23,4 °C (25. 07.) kod trešnje. Rezultati mjerenja ukazuju kako tijekom istraživanog razdoblja i na obje istraživane dubine tla nema statistički značajne razlike u temperaturnom režimu tla između voćnjaka jabuke i trešnje.

**Ključne riječi:** temperatura tla, vegetacijsko razdoblje, jabuka, trešnja



## Udio različitih frakcija humusa u tlu

Jelena Pena, Katarina Perić, Vladimir Ivezić

*Fakultet agrobiotehničkih znanosti Osijek, Sveučilište Josipa Jurja Strossmayera u Osijeku, Vladimira Preloga 1, Osijek, Hrvatska (vivezic@pfos.hr)*

### Sažetak

Sadržaj humusa u poljoprivrednim tlima je u opadanju što se uglavnom dovodi u vezu s intenzifikacijom poljoprivrede tj. povećanim korištenjem mineralnih gnojiva, a smanjenjem korištenja organskih gnojiva. Standardne analize određivanja humusa u tlu koriste bikromatnu metodu mokrim spaljivanjem (Walkley and Black). Analize se vrše na uzorcima tla prosijanim kroz sito promjera 2 mm. No, vrlo često tako prosijani uzorci tla rezultiraju s velikim varijabilnostima u rezultatima pa se uzorci dodatno melju kako bi se postigla veća finoća čestica promjera 0,25 mm. Cilj našeg istraživanja je bio odrediti udio dvije frakcije humusa: a) < 0,25 mm te frakcije b) 0,25 mm – 2 mm kako bi utvrdili postotni udio frakcije koja utječe na velike varijabilnosti u rezultatima. Analizirano je 216 uzoraka tla s dva lokaliteta u blizini Feričanaca te je na svakom lokalitetu na pola parcela korišteno organsko gnojivo (OG) koje je utjecalo na ukupan sadržaj humusa. Rezultati su pokazali visoku pozitivnu korelaciju između dvije frakcije humusa ( $p < 0.001$ ). Prosjek sadržaj humusa svih 216 uzoraka tla je bio 2,2% od čega je frakcija „a“ sačinjavala 1,6 % humusa a frakcija „b“ 0,6% humusa. Dakle frakcija „b“, koja utječe na varijabilnost rezultata kada se humus određuje samo prosijavanjem kroz sito od 2mm, bez dodatnog usitnjavanja, je 27% tj. 1/3. Primjena organskog gnojiva je utjecala na ukupan sadržaj humusa pa je tako na parcelama s OG ukupan sadržaj humusa bio 2,3% od čega je frakcija „b“ iznosila 0,6% što je 26% od ukupne frakcije, dok je bez OG ukupan sadržaj humusa bio 2,1% a frakcija „b“ je također iznosila 0,6% što je 28% od ukupne frakcije. Radi dobivanja što preciznijih rezultata humusa u tlu preporuča se drobljenje ili meljava uzoraka tla na finije čestice (< 0,25).

**Ključne riječi:** bikromat metoda, prosijavanje uzoraka, promjer čestica



## Količina mikroelemenata u mrkvi iz različitih prodajnih kanala

Marko Petek<sup>1</sup>, Tomislav Karažija<sup>1</sup>, Boris Lazarević<sup>1</sup>, Mihaela Šatvar<sup>1</sup>, Ivona Pavić<sup>2</sup>, Mirjana Herak Čustić<sup>1</sup>

<sup>1</sup>Sveučilište u Zagrebu Agronomski fakultet, Zavod za ishranu bilja, Svetošimunska 25, Zagreb, Hrvatska (\*autor za kontakt: Tomislav Karažija, tkarazija@agr.hr)

<sup>2</sup>Sveučilište u Zagrebu Agronomski fakultet, Svetošimunska 25, Zagreb, Hrvatska, studentica

### Sažetak

Povrće je moguće proizvoditi na konvencionalni i organski način, te se takvo povrće i nalazi na tržištu. Ovisno o načinu proizvodnje razlikuje se i mineralni sastav povrća. Cilj istraživanja bio je utvrditi razlike u količinama mikroelemenata na tržištu grada Zagreba iz 3 različita prodajna kanala. Uzorkovanje je u triplikatu provedeno u 5 trgovačkih centara, na 5 tržnica i u 5 trgovina organskim proizvodima. Nakon digestije suhog biljnog materijala koncentriranom HNO<sub>3</sub>, željezo, mangan, cink i bakar određeni su atomskom apsorpcijskom spektrometrijom. Prosječne količine mikroelemenata u trgovačkim lancima, na tržnicama i u trgovinama organskim proizvodima kretale su se od 15,34-29,61 mg Fe kg<sup>-1</sup>, 7,97-9,07 mg Mn kg<sup>-1</sup>, 14,62-14,87 mg Zn kg<sup>-1</sup>, 4,38-6,11 mg Cu kg<sup>-1</sup>. Nije utvrđena pravilnost u količinama mikroelemenata obzirom na izvor prodaje.

**Ključne riječi:** *Dacus carota*, željezo, mangan, cink, minerali



## Use of VNIR spectroscopy for assessment of Stagnosols properties based on linear and non-linear calibration methods

Ivana Šestak, Milan Mesić, Željka Zgorelec, Aleksandra Perčin

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia ([isestak@agr.hr](mailto:isestak@agr.hr))*

### Abstract

Soil organic and mineral compounds can be estimated non-destructively by visible and near infrared (VNIR) diffuse reflectance spectroscopy. However, results of calibration models differ in dependence of measurement precision, spectral range, variability of soil properties and calibration methods used for prediction. The objective of research was to estimate the ability of hyperspectral VNIR spectroscopy for field-scale prediction of soil total carbon (TC %) and total nitrogen (TN %) content, soil pH, plant-available potassium (K) and phosphorus (P), in arable Stagnosols. Total of 200 soil samples taken from field experiment (soil depth: 30 cm; sampling grid: 15x15 m; 2016) were scanned in laboratory using portable spectroradiometer (FieldSpec®3: 350-1050 nm; ASD Inc., USA). Partial least square regression (PLSR) with full cross-validation and artificial neural networks (ANN) were used to build prediction models of selected soil properties based on VNIR spectra. Strong to full correlation and low root mean square error were obtained between predicted and measured values for the calibration and validation dataset, and both calibration methods. ANN models were more efficient in capturing the complex link between selected soil properties and soil reflectance spectra. Key spectral features and algorithms defined in this study should help to support site-specific and real-time soil survey using hyperspectral remote sensing.

**Key words:** soil reflectance, principal component analysis, linear modeling, neural networks, soil quality



## Parametri antropogenog zbijanja, kvarenja strukture i stvaranja pokorice kod različitih načina obrade tla

Andrija Špoljar<sup>1</sup>, Ivka Kvaternjak<sup>1</sup>, Ivica Kisić<sup>2</sup>

<sup>1</sup>Visoko gospodarsko učilište u Križevcima, M. Demerca 1, Križevci, Hrvatska (aspoljar@vguk.hr)

<sup>2</sup>Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska cesta 25, Zagreb, Hrvatska

### Sažetak

Istraživanja su provedena na pokušalištu Visokog gospodarskog učilišta u Križevcima (N: 46<sup>0</sup>01'12<sup>11</sup> E:16<sup>0</sup>34'28<sup>11</sup>). Na pet različitih varijanata obrade tla uzgajani su jari usjevi u plodosmjeni: kukuruz (*Zea mays L.*) u 2008. godini i soja (*Glycine max L.*) u 2009. Cilj istraživanja bio je utvrditi utjecaj različitih načina i rokova obrade na antropogeno zbijanje, kvarenje strukture i opasnost od stvaranja pokorice, kako bi se mogao preporučiti najpovoljniji način i rok obrade tla. Najpovoljnije stanje stabilnosti strukture (St), utvrđeno je kod varijante A kod koje je osnovna obrada i priprema tla sjetvo-spremačem provedena u proljeće, dok je najnepovoljnije stanje utvrđeno kod varijante E s najvećim brojem zahvata obrade. Najveća vrijednost ovog parametra i najmanja opasnost od zbijanja tla i erozije zabilježena je nakon uzgoja soje. Najveće vrijednosti gustoće pakiranja čestica tla (Gp) nakon berbe kukuruza bile su kod varijanata D i E kod kojih je osnovna obrada tla provedena u jesen. U obje godine istraživanja utvrđen je najmanji rizik od stvaranja pokorice (R) kod varijante A, a najveća vrijednost ovog parametra i ujedno najpovoljnije stanje bilo je nakon uzgoja soje. Temeljem navedenoga, sa stanovišta održivog gospodarenja tlom, može se preporučiti osnovna obrada tla u proljeće i njegova priprema sjetvo-spremačem.

**Ključne riječi:** obrada tla, parametri antropogenog zbijanja





## Anthropogenic compaction parameters, structure deformation and surface sealing in different soil treatment methods

Andrija Špoljar<sup>1</sup>, Ivka Kvaternjak<sup>1</sup>, Ivica Kisić<sup>2</sup>

<sup>1</sup>Visoko gospodarsko učilište u Križevcima, M. Demerca 1, Križevci, Hrvatska (aspoljar@vguk.hr)

<sup>2</sup>Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska cesta 25, Zagreb, Hrvatska

### Abstract

Research has been conducted at Križevci College of Agriculture (N: 46<sup>0</sup>01'12<sup>11</sup> E:16<sup>0</sup>34'28<sup>11</sup>). The following crops were cultivated on five different variants of soil cultivation in crops rotation: maize (*Zea mays L.*) in 2008 and soybean (*Glycine max L.*) in 2009. The aim of the research was to determine the influence of different methods and treatment times on anthropogenic compaction, structure deformation and the risk of surface sealing, in order to recommend the optimal method and time of soil treatment. The most favorable condition of structure stability (St) was found in variant A at which primary treatment and soil preparation with seed harrow was carried out in the spring, while the most unfavorable condition was found in variant E with the largest number of treatments. The greatest value of this parameter and the lowest risk of soil compaction and erosion was observed after soybean growing. The highest density values of the soil particle size (PD) after corn harvesting were in D and E variants where the basic soil treatment was carried out in autumn. In both research years, the lowest risk of surface sealing formation (R) was determined in A variant, and the highest value of this parameter and the most favorable condition was after soybean cultivation. From the point of view of sustainable soil management and based on the facts mentioned above, basic soil treatment, as well as its preparation with a seed harrow is recommended in the spring.

**Keywords:** soil treatment, anthropogenic compaction parameters



## Spatial variability of soil physical and chemical properties in Croatian olive groves

Branimir Urlić<sup>1</sup>, Filip Pošćić<sup>1</sup>, Marija Romić<sup>2</sup>, Helena Bakić Begić<sup>2</sup>, Nevenka Mikac<sup>3</sup>, Marko Runjić<sup>1</sup>, Maja Jukić Špika<sup>1</sup>, Zed Rengel<sup>4</sup>, Niko Bačić<sup>3</sup>, Mavro Lučić<sup>3</sup>, Željka Fiket<sup>3</sup>, Tatjana Klepo<sup>1,5</sup>, Slavko Perica<sup>1,5</sup>

<sup>1</sup>*Institute for Adriatic Crops and Karst Reclamation, Put Duilova 11, 21000 Split, Croatia*

<sup>2</sup>*Faculty of Agriculture, University of Zagreb, Svetošimunska cesta 25, 10000 Zagreb, Croatia*

<sup>3</sup>*Ruđer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia*

<sup>4</sup>*School of Agriculture and Environment, University of Western Australia, 35 Stirling Highway, Perth WA 6009, Australia*

<sup>5</sup>*Centre of Excellence for Biodiversity and Molecular Plant Breeding, Svetošimunska cesta 25, 10000 Zagreb, Croatia*

### Abstract

As the olive oil is considered to be one of the most mislabeled products in Europe it is of great importance to develop a standard methodology for reliable determination of the olive oil origin. For that purpose during 2016-2017 we implemented the project on “Role of soil properties and environmental conditions in elemental and isotopic composition of the olive: basis for oil geographic traceability” funded by the Unity through Knowledge Fund (UKF). In particular, the objectives were to explore the relations between physical and chemical soil fingerprint, the geographical location and the related olive oil. In this particular study, we will present the aims of the UKF project to a wider audience though we will focus mostly on the soil physical and chemical properties in Croatian olive groves. We determined pH, total carbonates and 47 elements, both total and available, in top-soil of 50 olive groves (172 samples). Olive groves were located in Croatian olive-growing regions spanning from Istria to South Dalmatia. Samples were divided according to soil classification and compared for their plant-nutrient limitation. The discussion will relate to soil deficiencies and appropriate agronomic techniques for an optimization of measures for olive groves.

**Key words:** olive groves, mediterranean area, terra rossa, rendzina, reclaimed karst



## Biodiagnostic of agro-grey soil fertility

Roman Ushakov, Nastya Ruchkina

*Department of Forestry, Agro-Chemistry and Ecology, Ryazan State Agrotechnological University  
Named after P.A. Kostychev, Ryazan, Russia, Kostychev St. (r.ushakov1971@mail.ru)*

### Abstract

The aim of the research was studying the activity of the agro-gray soil micro flora in a case of unfavorable factors - heavy metals and high acidity to evaluate soil fertility. In conditions of agro-gray soils, the assessment of soil fertility from the standpoint of stability based on microbiological studies is conducted for the first time. The object of the research was agro-gray soil of different cultural state: fertile (cultivated) and infertile (uncultivated). The uncultivated agro-gray soil had 2.2-2.5 % humus, when ecologically and economically reasonable 3 %, and medium nutrients. The cultivated soil had 5.4 % humus and high labile phosphorus and exchangeable potassium. The cultivated variant reflects the potential of the soil to ensure sustainability. Acidification and contamination with heavy metals were simulated in the experiments. Soil pollution was produced by cadmium at the rate of 10, 30 and 100 MAC. The exposure was 1, 10, 35 and 57 days. Soil acidification was simulated by adding dilute sulfuric acid to have acid load equal to 0.018, 0.044 and 0.120 mM/l. Microbiological activity was determined by conventional methods. The cultivated agro-gray soil did not have micro flora suppressed by cadmium contamination and acidification. In an experiment with contamination, microbial biomass was greatest in fertile soil. With a background concentration, it was 1187  $\mu\text{g C/g soil}$  for 1 day, 1590  $\mu\text{g C/g soil}$  for 10 days 1005  $\mu\text{g C/g soil}$  for 35 days and 891  $\mu\text{g C/g soil}$  for 57 days, which respectively was 540; 761; 541 and 554  $\mu\text{g C/g soil}$  more than in the infertile variant. At a background pH of 6.0, the total number of microorganisms was  $41.64 \cdot 10^6 \text{ CFU/g}$  and after acid addition 0.018 mM/l (pH 5.3) it decreased to  $19.16 \cdot 10^6 \text{ CFU/g}$ , then to  $15.80 \cdot 10^6 \text{ CFU/g}$  and  $12.00 \cdot 10^6 \text{ CFU/g}$ , respectively, with a load of 0.044 and 0.120 mM/l.

**Keywords:** agro-gray soil, tolerance, bioindication, microbiological activity.



## Potential of olive pomace as soil amendment

Zoran Užila<sup>1</sup>, Igor Palčić<sup>1</sup>, Marko Černe<sup>1</sup>, Igor Pasković<sup>1</sup>, Nikola Major<sup>1</sup>, Josipa Perković<sup>1</sup>,  
Marina Lukić<sup>1</sup>, Smiljana Goreta Ban<sup>1</sup>, Aleksandra Perčin<sup>2</sup>, Marina Diana Igrc<sup>2</sup>, Marija  
Romić<sup>2</sup>, Dean Ban<sup>1</sup>

<sup>1</sup> *Institute of Agriculture and Tourism, Karla Huguesa 8, Poreč, Croatia (zoran@iptpo.hr)*

<sup>2</sup> *Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia*

### Abstract

Olive oil production is a very significant economic activity, especially in the Mediterranean part of Croatia. However, except the economic aspect, olive oil production can significantly affect the environment. One of the byproducts of olive oil production is olive pomace, whose quantities are becoming a significant problem and it is necessary to find an adequate solution for olive pomace disposal. One of the possible solutions is the valorization of olive pomace in the form of soil amendment. The aim of the present research was to determine the variability in chemical composition of olive pomaces from different olive mills across Croatia. In the collected samples, macro and microelements, dry weight and oil percentage were analyzed. In the analyzed samples, a significant variability was established as follows: N (0,59-1,38%), C (55,27-59,72%), P (3,72-17,89 g/kg), K (3,1-20 g/kg), Ca (0,9-1,5 g/kg), Fe (7,4-274 g/kg), Mg (131-637 mg/kg), Mn (3,2-11 mg/kg), Zn (4,1-10 mg/kg). Dry weight percentage varied from 19,29 to 82,97%, while oil percentage from 4,53 to 18,41%. Determined macro and microelements contents confirmed the potential of olive pomace as a valuable soil amendment, which would allow to return the nutrients from the olives into the soil. However, it is necessary to develop a pomace processing technology that will degrade the residual oils so that soil fertility will not be affected.

**Key words:** biomass, fertilizer, macroelements, microelements, olive oil



## Potencijal komine maslina kao poboljšivača tla

Zoran Užila<sup>1</sup>, Igor Palčić<sup>1</sup>, Marko Černe<sup>1</sup>, Igor Pasković<sup>1</sup>, Nikola Major<sup>1</sup>, Josipa Perković<sup>1</sup>,  
Marina Lukić<sup>1</sup>, Smiljana Goreta Ban<sup>1</sup>, Aleksandra Perčin<sup>2</sup>, Marina Diana Igrc<sup>2</sup>, Marija  
Romić<sup>2</sup>, Dean Ban<sup>1</sup>

<sup>1</sup> Institut za poljoprivredu i turizam, Karla Huguesa 8, Poreč, Hrvatska (zoran@iptpo.hr)

<sup>2</sup> Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska

### Sažetak

Proizvodnja maslinovog ulja predstavlja značajnu ekonomsku granu, posebice u mediteranskom području Hrvatske. Međutim, osim ekonomskog aspekta, proizvodnja maslinovog ulja može značajno utjecati na okoliš. Jedan od nusproizvoda proizvodnje maslinovog ulja jest komina, čije količine postaju sve značajnije te je nužno pronaći odgovarajuće rješenje za njezino zbrinjavanje. Jedno od mogućih rješenja jest valorizacija komine u smislu poboljšivača tla. Cilj provedenog istraživanja bio je utvrditi varijabilnost u kemijskom sastavu komine iz različitih uljara diljem Hrvatske. U sakupljenim uzorcima određene su količine makro i mikroelemenata, suha tvar i udio ulja. U analiziranim uzorcima utvrđena je značajna varijabilnost, kako slijedi: N (0,59-1,38%), C (55,27-59,72%), P (3,72-17,89 g/kg), K (3,1-20 g/kg), Ca (0,9-1,5 g/kg), Fe (7,4-274 g/kg), Mg (131-637 mg/kg), Mn (3,2-11 mg/kg), Zn (4,1-10 mg/kg). Postotak suhe tvari varirao je od 19,29 do 82,97%, dok se postotak ulja kretao od 4,53 do 18,41%. Utvrđene količine makro i mikroelemenata predstavljaju izniman potencijal za valorizaciju komine u obliku poboljšivača tla čime će se hraniva proizašla iz plodova masline ponovo vratiti u tlo. Međutim, potrebno je razraditi tehnologije obrade komine kako bi se razgradila preostala ulja koja mogu negativno utjecati na pogodnost tla za uzgoj poljoprivrednih kultura.

**Ključne riječi:** biomasa, gnojivo, makroelementi, mikroelementi, maslinovo ulje



## Soil organic matter in agricultural soils of Eastern Croatia

Vladimir Zebec, Vladimir Ivezić, Zdenko Lončarić, Domagoj Rastija

*Faculty of Agrobiotechnical Sciences Osijek, University of J.J. Strossmayer in Osijek, Vladimira Preloga 1, Osijek, Croatia (vzebec@pfos.hr)*

### Abstract

Soil organic matter content is one of the main issues of European soils and agriculture in general. It is the basis for balancing nutrients and issuing fertilizer recommendations for achieving high and stable yields. The aim of the research is to determine the content of organic matter in the arable horizons in different soils at Eastern Croatia. The study was conducted on 165 locations and 9 dominant soil types in Eastern Croatia including their arable horizons. The soil organic matter was determined based on the organic carbon content (C) followed by sulfochromic oxidation prescribed in ISO 14235. According to the determined analytical values of organic matter content, studied soil samples were classified into five categories: very low organic matter content of the soil (<1% organic matter) 1 soil sample, low organic matter soils (1–3% organic matter) 119 soil samples, plenty of organic matter content of the soil (3–5% organic matter) 37 soil samples, intensely organic matter soils (5–10% organic matter) 7 soil samples and extremely intense organic matter soils (>10% organic matter) 1 soil sample. The average value of organic matter if we look at all the investigated samples, was 2,65%, with a range from minimum of 0,83% to maximum of 11,80%. The maximum average value of organic matter content in the soil was determined in the humic gleysols (4,94 %) and it is statistically higher in comparison to other investigated soils. Decrease of organic matter was determined according to the soil type: humic gleysols (4,94%) < stagnic gleysols (3,25%) < gleysols (2,68%) < eutric cambisol (2,51%) < fluvisol (2,43%) < endogleyic stagnosol (2,37%) < stagnosol (2,26%) < luvic stagnosol (1,93%) < luvisol (1,87%).

**Key words:** organic matter, soil type, eastern Croatia



## Evaluation of leaching potential of nutrients from vineyards soil

Monika Zovko, Marina Bubalo Kovačić, Lana Filipović, Vilim Filipović, Filip Kranjčec,  
Gabrijel Ondrašek

*Faculty of Agriculture, University of Zagreb, Svetošimunska 25, Zagreb, Croatia (mzovko@agr.hr)*

### Abstract

Vineyard fertilization practices is an important part of managing a vineyard since it impacts on vine growth, crop yield and wine quality. However, there are concerns about the of-site impacts of vineyard nutrient losses (especially of N and P) on the water quality standards. This research was carried out in two vineyards chosen as study plots (SP) for their heterogeneous pedological and climate characteristics: (SP1) located in the coastal wine-growing region, prevalent soil type is hydroameliorated- pipe drainage regosol and (SP2) located in the continental wine-growing region, prevalent soil type is Rigosol from Pseudogley of sloping terrains developed on Pleistocene loam and Pliocene clay substrata on a hillslope terrain. The physical and hydrologic characteristics of the soils were determined from soil samples collected from both SP. Lysimeters were installed at both SP and undisturbed soil columns taken from both locations for the assessment of nitrate and phosphate downward mobility through the soil profile by applying irrigation and a known nutrients concentration (in correspondence to the applied agricultural practices). Water samples from lysimeters and leachate from soli columns were taken periodically depending on rainfall occurrence and analyzed for nitrate, nitrite, ammonium and phosphate concentrations. The SP1 generated more intensive drainage and higher nutrient leaching than the SP2. This study demonstrates that the risk of nutrient leaching from each SP is a combination of factors associated with the soil texture, infiltration rate, field capacity. Still, the possibility of nutrients losses from vineyards soils through the erosion, surface runoff and subsurface leaching will be further studied.

**Key words:** agricultural soil, soil and water quality, lysimeter, fertilization





## Višegodišnji utjecaj organske gnojidbe na količinu i dinamiku mikroelemenata u lišću vinove loze (*Vitis vinifera* L.)

Tomislav Karažija<sup>1</sup>, Marko Petek<sup>1</sup>, Boris Lazarević<sup>1</sup>, Mirjana Herak Ćustić<sup>1</sup>, Tihana Kešer<sup>2</sup>

<sup>1</sup> Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska ([tkarazija@agr.hr](mailto:tkarazija@agr.hr))

<sup>2</sup> Agronomski fakultet Sveučilišta u Zagrebu, Svetošimunska 25, Zagreb, Hrvatska, student

### Sažetak

Cilj ovog istraživanja bio je utvrditi utjecaj različitih doza organskih gnojiva na količinu i dinamiku mikroelemenata u lišću vinove loze na karbonatnom tlu tijekom tri vegetacije. U istraživanje je bilo uključeno šest varijanti gnojidbe (kontrola-bez gnojidbe, 20 t ha<sup>-1</sup> zrelog stajskog gnoja, 40 t ha<sup>-1</sup> zrelog stajskog gnoja, 20 000 l ha<sup>-1</sup> kiselog treseta, 40 000 l ha<sup>-1</sup> kiselog treseta i 500 kg NPK 5:20:30 ha<sup>-1</sup> s dvije prihrane UREOM po 100 kg ha<sup>-1</sup>). U svakoj vegetaciji izvršena su tri uzorkovanja (cvatnja, 2 tjedna poslije cvatnje, šara). Statistički značajna razlika u količini željeza u lišću utvrđena je u prvoj godini uzorkovanja (šara), a prema prosječnim godišnjim vrijednostima tretmana u trećoj. Statistički značajna razlika u količini mangana zabilježena je u drugoj godini istraživanja (cvatnja), dok je kod prosječnih godišnjih vrijednosti tretmana razlika utvrđena u prvoj i trećoj godini. Kod cinka i bakra u sve tri godine istraživanja nisu utvrđene statistički značajne razlike.

**Ključne riječi:** stajski gnoj, treset, mikroelementi, vinova loza, karbonatno tlo





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