University of Belgrade, Institute of Chemistry, Technology and Metallurgy
Centre of Excellence in Environmental Chemistry and Engineering

Book of Abstracts

COST ES1306 SCIENTIFIC WORKSHOP
"Connectivity as a tool to understand water/soil/sediment pollution"

Belgrade, Serbia 4-6 December 2017

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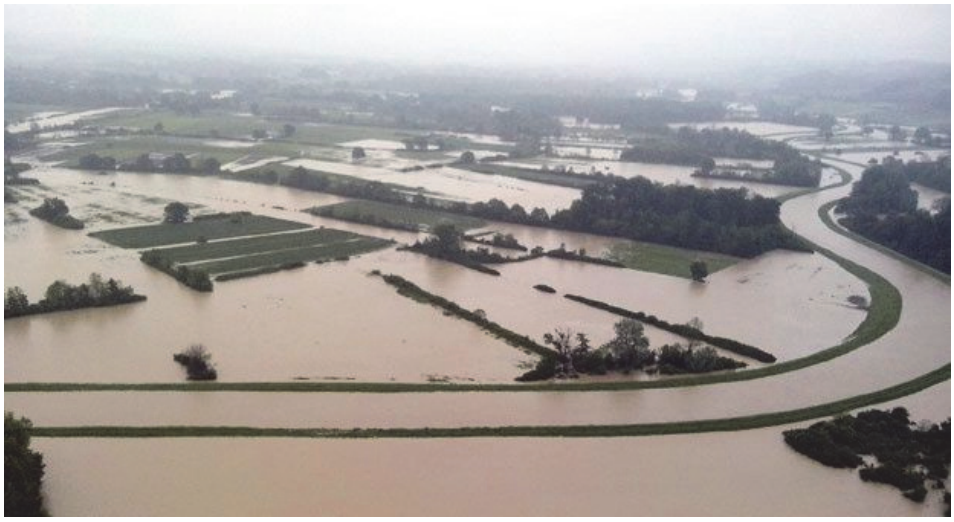

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Connecteur
Connecting European Connectivity Research

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A Word from the Editor

The meeting "Connectivity as a tool to understand water/soil/sediment pollution" is aimed at understanding connectivity and changes in connectivity due to climate change from anthropogenic pollutions sources in catchments to coastal areas.

In May 2014, heavy rain hit Serbia. Record precipitation – more than 200 mm in one week in western Serbia, which is equal to the amount of three-month precipitation under the usual conditions. Floods activated over 3000 landslides and affected about 1.6 million people living in 38 municipalities and cities that are located mainly in central and western Serbia.

About 40% of total damage was caused by soil contamination by pollutants released from industrial objects, waste material from the antimony mine, waste dumps, and ash dumps of coal fired thermal plants.

We need to better understand how these pollutants enter the water, soil and sediments and how they are transported within the landscape. Connectivity can serve as a tool to look at pollutant pathways and mitigation measures.

Within this meeting, we plan to see the coal fired thermal plants (Drmno and Kostolac) along Danube River as well as Đerdap National Park to understand how the maintenance of the connectivity plays a role in sediment transport, pollution migration, pollution control, and clean environment in a changing climate

Belgrade, December 2017

Editor

Dr Dragana Đorđević

Workshop Timetable (Belgrade, Serbia, 4-6 December 2017)

Venue: Institute for Chemistry, Technology and Metallurgy – University of Belgrade, Center of Excellence for Environmental Chemistry and Engineering Njegoševa 12, Belgrade

Day 1 4 December 2017
9:00 Welcome
9:45 – 10:30
Prof. Dr Vladimir Đurđević
"Climate change in South East Europe - observed trends and projections of future changes"
10:30 – 11:00
Coffee break
11:00 – 12:30
Prof. Dr Ratko Ristić
"The role of land management in the process of disaster risk reduction, mitigation and adaptation to effects of climate changes"
Prof. Dr Artemi Cerdà
"Changes in connectivity after forest fires"
12:30 – 14:00
Lunch break (provided)
14:00 – 15:30
Julián Campo, María Lorenzo, Vicente Andreu, Yolanda Picó
"Presence of emerging persistent organic pollutants (POPs) in water, sediment and biota of a Mediterranean wetland (Jucar and Turia River basins, Spain)"
Dr Miloš Ćirić
"Is the future blue-green?"
Dr Sanja Sakan
"Potential harmful elements in surface sediments form Serbian rivers"
15:30 – 16:00
Coffee break
16:00 – 17:30

Prof. Dr Biljana Škrbić
"Contamination of cultivated vegetables by heavy elements from flooded arable soil: Human exposure"
Dr Dragana Đorđević
"Chemical patterns of elements from soils and river sediments as tracers of sediment migration" (STSM of Connecteur COST Action ES1306-34336: grant holder Dragana Đorđević)

Day 2 5 December 2017
Excursion: National park Djerdap
8:00 Start in front of the Hotel Park
Lunch packets provided

Day 3 6 December 2017
9:00 – 10:30
Dr Milica Kašanin Grubin
"Provenance and pollution status of recent river sediments in Serbia"
Sanja Šešlija:
"Bio-based polymers: Steps towards environmental responsibility"
Gordana Grujić
"Soil and Water Pollution of the Flood Affected Area along the Drina River"
10:30 – 11:00
Coffee break
11:00 – 12:30
Nikola Teslas' Musemum visiting (optional)
Concluding remarks
12:30 – 14:00
Lunch break (provided)

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Plenary Lecture

CLIMATE CHANGE IN SOUTH EAST EUROPE - OBSERVED trends AND PROJECTIONS OF FUTURE CHANGES

Vladimir Đurđević

Institute of meteorology, Faculty of physics, University of Belgrade, Dobracina 16, Belgrade, Serbia
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Since industrial revolution different human activities substantially contributed to the change of atmospheric composition. The most significant change is related to the intensive use of fossil fuels as a main source for energy production. Anthropogenic emissions of different greenhouse gases which are byproduct of combustion, on the first place of coal, oil and natural gas, was contributed to the increase of concentration of these gases in the atmosphere. The most remarkable is increase in CO2 concentration, due to this disturbance in natural cycle of carbon. Concentration of CO2 increased above 40% in comparison to the preindustrial levels of about 270 ppm. Because of these increases of concentrations of greenhouse gases, additional heat that is trapped by this effect lead to increase of global surface air temperature of about 1 °C since late nineteenth century, followed by decrease in ice sheet mass, sea level rise, redistribution of rain patterns and other associate changes in climate system. This global change can also be tracked in the region of Southeast Europe. Annual mean temperature was increased of about 1.2 °C in comparison to the mean values of the mid-twentieth century, together with significant increase in number and duration of periods with extremely high temperature. On the other side measurements reveals that precipitation patterns changed in the way that dry periods are prolonged, and other the other side positive trend in extreme precipitation amounts is registered in majority meteorological stations. Results of climate projections obtained by regional climate model reveals that these observed trends will continue in the future if global emissions of the greenhouse gasses stay at the current level. In this case the region will face increase of annual mean temperature of about 4 °C at the end of this century. Southern parts can expect shift to the arid climate in the future, but whole region can expect significant decrease in summer precipitation. Both positive temperature and precipitation extremes are expected to increase in the future under this business as usual scenario.

Acknowledgements

The study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project: III43007).

Invited Lectures

THE ROLE OF LAND MANAGEMENT IN THE PROCESS OF DISASTER RISK REDUCTION, MITIGATION AND ADAPTATION TO EFFECTS OF CLIMATE CHANGES

Ratko Ristić

University of Belgrade Faculty of Forestry, Chair for Torrents and Erosion
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Torrential floods are the most frequent natural catastrophic event in Serbia, which cause the loss of human lives and huge material damage, both in urban and rural areas. The analysis of the intra-annual distribution of maximal discharges aided in noticing that torrential floods have a seasonal character. The erosion and torrent control works (ETCWs) in Serbia began at the end of the XIX century. Effective protection from torrential floods encompasses biotechnical works on the slopes in the watershed and technical works on the torrent beds, within a precisely defined administrative and spatial framework in order to achieve maximal safety for people and their property. Cooperation to overcome the conflicts between the sectors of the water resources management, forestry, agriculture, energetics, environmental protection and local economic development groups are indispensable at the following levels: policy, spatial planning, practice, investments and education.

Torrential (flash) flood represents a sudden appearance of maximal discharge in a torrent bed with a high concentration of sediment. In extreme cases, the two-phase fluid flows out from the torrent bed, with enormous destructive energy. The two-phase fluid (water and sediment) can contain fractions (60% of total volume) with different granulations ranging from clay particles to rock fragments, with a diameter of up to 5.0 m and a mass of over 200 tons. **Torrential watershed** is a hydrographic entity which involves the beds of the mainstream and its tributaries, and the gravitating surfaces with erosion processes at a certain level of intensity. The attribute **"torrential"** refers to any watershed with a sudden appearance of maximal discharge with a high concentration of sediment, regardless of the size and category of the stream. A total of 12.000 torrential watersheds were registered in Serbia.

Torrential floods that once occurred rarely during the pre-development period have now become more frequent and destructive due to the transformation of the land usage in the watersheds, from rural into urban land usage. The decrease of surfaces covered with forest vegetation, along with urbanization and inadequate agricultural measures are some of the negative aspects of human activities that cause torrential floods. Due to these activities former discharges with a 100-year recurrence interval have become events with a 20-year recurrence interval. Along with the watershed development, there are changes in its hydrological regime that increase the torrential flood volume. The soil and vegetation cover directly affects the intensity of the surface runoff by creating "losses" of precipitation through the processes of interception, evaporation, transpiration and infiltration. The eroded

soil becomes compacted with an insufficient amount of nutrients and organic matter. The infiltration rates and water-storage capacity of the soil profile are reduced which, in turn, increases the overland flow and erosion. The amount of surface runoff depends on the total precipitation, the type of land usage, and the characteristics of the vegetation cover and the air and water capacity of the soil.

The climate, along with the specific characteristics of the relief, distinctions of the soil and vegetation cover, severe erosion processes and social-economic conditions resulted in the frequent occurrence of torrential floods. Erosion processes of different categories of destruction are present in 76,355 km^2 (86.4% territory of Serbia) in Serbia. The average annual production of erosive material in the territory of Serbia is $37.25 \cdot 10^6$ m^3, in other words, 487.85 $m^3 \cdot km^{-2}$, which is 4.88 times more than the geological (natural) erosion. The average rate of soil formation on the slopes in Serbia is 0.1 $mm \cdot year^{-1}$. Geological (natural) erosion is the action of wind, water, ice and gravity in wearing away the soil at a rate smaller than 0.1 $mm \cdot year^{-1}$ ($\leq$ 100 $m^3 \cdot km^{-2} \cdot year^{-1}$). It is a relatively slow, continuous process unlike accelerated erosion, which produces a rate of soil loss higher than 0.1 $mm \cdot year^{-1}$ (> 100 $m^3 \cdot km^{-2} \cdot year^{-1}$) due to human activities.

Severe and excessive erosion processes cover 35% of the territory of Serbia. With local economic development, soil erosion becomes more frequent and severe. The construction of roads and residential areas and the inappropriate use of agricultural and forest land contribute to the concentration of fast surface runoff, as well as sediment transportation from the gravitating surfaces to the channel network. The roads interact positively with clear cutting. They modify the hill slope flow paths and cause faster delivery of the water to the channels during storm events with the conversion of the subsurface flow into surface flow. Such flows contribute 20 to 60 times more sediment (unsealed roads) than undisturbed forest surfaces and about 10 times more sediment than harvested areas. Clear cutting and removal of the vegetation influence the water balance by affecting evapotranspiration and possibly snow accumulation and melt. These activities increase the peak discharge by as much as 50% in small basins and 100% in large basins. Timber harvesting has the potential to increase the total flow and lengthen the duration of larger flows while enabling sediment movement. Steep terrains without vegetation are particularly prone to increased surface runoff and erosion, like ski runs with decreased surface roughness and increased velocity of runoff and sediment yield.

LONG-TERM CHANGES IN SOIL EROSION DUE TO FOREST FIRES

Artemi Cerdà

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Soils are affected by the impacts of wildfires. Soil erosion rates are highly affected by forest fires due to the removal of the above ground vegetation, the heat impact on the soil, the reduction of the organic matter, the ash cover, and the changes introduced by the rainfall on the soil surface . Most of the research carried out on forest fire affected land paid attention to the "window of disturbance", which is the period that the soil losses are higher than before the forest fire and that last for few years. However, the spatial and temporal variability of soil erosion is very high as a result of the uneven temporal and spatial distribution of the rainfall, and the window of disturbance cannot be easily found under natural rainfall. In order to understand the evolution of soil erosion after forest fires it is necessary to monitor fire affected sites over a long period of time, which will enable the assessment of the period affected by the window of disturbance (see Cerdà and Doerr, 2005). However, it is also possible to do measurements and experiments in areas with a different fire history. This will give us information about the temporal changes in soil erosion after forest fire. To reduce the spatial variability of rainfall we can use simulated rainfall that can be applied at multiple site with the same rainfall intensity and duration. For this purpose rainfall simulation can be of great help, in the laboratory.

In order to determine how fire and post-fire changes change soil erosion rates we selected 12 research sites at the study area of the Massís del Caroig, Eastern Spain, which suffered different fires in the last century. The parent material is limestone in all study sites and the mean annual rainfall ranges from 480 to 550 mm per year in average. The vegetation consists of scrubland (Maquia) with different species. In the years after the fire Brachypodium retusum, Thymus vulgaris, Fumana Ericoides, Cistus Albidus, Ulex parviflorus or Rosmarinus officinalis regenerated, but after some years dense shrub cover develops with typical species such as Quercus coccifera, Quercus ilex, Pistacia lentiscus and Junyperus oxycedurs. Soils are shallow (0-30 cm depth) and distributed in pockets of soil mixed with rock outcrops. All the selected plots were located on the middle tram of the slopes to avoid differences, although previous studies showed no differences in infiltration rates, overland flow and soil erosion on the different trams of the slopes on limestone (Cerdà, 1998d). Each site was selected upon the last fire registered: 0, 1, 2, 3, 5, 9, 16, 24, 33, 44, 51, and 63 years after the last fire. The measurements were carried out in August 2013 by means of a portable rainfall simulator. Ten plots of 0.25 m2 were selected at each site. Rainfall simulation at 55 mm h-1 during one hour was applied. The results show that immediately after the wildfires the soil erosion was negligible due to the ash cover, which acted as mulch, meanwhile after few months (1 year after the fire) the highest soil losses were measured. After 5 years the soil losses had reduced significantly and after 16 years were negligible.

PRESENCE OF EMERGING PERSISTENT ORGANIC POLLUTANTS (POPS) IN WATER, SEDIMENT AND BIOTA OF A MEDITERRANEAN WETLAND (JUCAR AND TURIA RIVER BASINS, SPAIN).

J. Campo[1], M. Lorenzo[2], V. Andreu[1], Y. Picó[2]

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The analysis of emerging persistent organic pollutants (POPs), as perfluoroalkyl substances (PFASs) and organophosphate flame retardants (PFRs), in environmental matrices ofMediterranean wetland zones is decisive for understanding the transport, accumulation and fate of these pollutants in areasunder high anthropogenic pressure. The determination of PFASs and PFRs was made by high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS). Target analytes were 9 PFRs and 21 PFASs. PFASs and PFRs were extracted from water, soil, sediment and biota in samples taken during the years 2010, 2012 and 2016. This was done by shaking and ultrasonication with methanol followed by solid-phase extraction (SPE) with STRATA-X cartridges. This SPE was also used as extraction procedure for water samples. Samples include as well wastewater treatment plant (WWTPs) influents, effluents and sludge.

Perfluorooctane sulfonate (PFOS) and tris(2-chloroisopropyl) phosphate (TClPP) were the compounds found at the highest concentrations in all samples. PFOS was also the most detected compound in sediment and fish samples while perfluorooctanoic acid (PFOA) was in all types of water samples. High levels of target compounds (mainly PFASs) found in WWTP effluents suggest the presence of precursors in water and their poor removal. PFRs tend to accumulate in sediment whereas water presents more PFASs. In the study area, the current replacement of long-chain PFASs (C>10) by short-chain ones in industrial and commercial applications and their increasing accumulation was observed.

Despite PFASs have been accumulating downstream in sediment and biota of the Jucar River catchment, concentrations reported can be considered at acceptable levels compared to existing Regulatory Legislation and, consequently, they do not pose an immediate human health risk. Monitoring of these compounds in zones under the threat of global change, as the Mediterranean, is required in order to manage and predict their possible effects on ecosystem services according to the European Water Framework Directive, particularly in the development of Special Action Plans in situations of alert and temporary drought in which contaminant concentrations could be increased

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''IS THE FUTURE BLUE-GREEN?''

Miloš Ćirić

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Climate-change studies related to the predictions of the effects of global warming as well as alterations in seasonal and interanual weather patterns on cyanobacterial populations include different approaches: observations in the field, modelling and experiments. The influence of the worldwide increase of air and surface water temperature could have direct and indirect implications for these photosynthetic prokaryotes, also known as blue-green algae. Cyanobacteria have higher temperature optima for growth in comparison with other eukaryotes in the phytoplankton, so they could directly benefit from increased water temperature in the future. Moreover, milder winters could cause changes in spring and early summer plankton phenology leading to the overexploitation of nutrients in the water column and potentially more frequent blooms of cyanobacteria. In spite of the fact that our results rely only on recent observations in the field, the occurrence of (sub)tropical species *Cylindrospermopsis raciborskii* observed in Serbian fish ponds for the first time in the last decade could be attributed to the effects of global warming. According to one recent study the possible explanation for its northward shift would be that the earlier increase in water temperature permited earlier germination of overwintering resting stages and enabled *C. raciborskii* to spread to the temperate zone. On the other hand, the predicted indirect effects of global warming on cyanobacterial populations are realized through two aspects: the strengthening of vertical stratification and the decreasing of the viscosity of water (for plankton organism this means lower resistance to sinking). There is a wide-accepted assumption that the thermal stratification will most likely intensify in a warmer world. This could provide an optimal buoyancy conditions for cyanobacteria which can give them a competitive advantage over other phytoplankton organisms in the water column.

Acknowledgements

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POTENTIAL HARMFUL ELEMENTS AND PERSISTENT ORGANIC POLLUTANTS IN SURFACE SEDIMENTS FROM SERBIAN RIVERS

Sanja Sakan, Dragana Đorđević

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Potentially hazardous trace elements are deemed serious pollutants due to their toxicity, persistence and non-degradability in the environment. Persistent organic pollutants (POPs) are group of organic chemicals that pose a threat to the environment despite no longer being in common use. POPs are hydrophobic and readily bind to the particle fraction in river waters. Via sedimentation processes, these contaminants are deposited to the basin bed. In Serbia, toxic elements appear to be the most prominent problem, although the elevated contents of organic pollutants have also been registered in some areas. The objective of this research was the evaluation of potential harmful elements and POPs contamination level in sediments of the most important rivers in Serbia. The toxic elements enrichment in studied sediments was conducted by using: determination of total metal content, sequential extraction procedure, quantification of the metal enrichment degree in the sediments by calculating geo-accumulation indices and determination of actual and potential element availability and application of BRAI index for the assessment of elements bioavailability. Surface sediments from studied rivers were examined by chemical analysis for POPs compounds: organochlorine pesticides, organochlorine pesticides, polychlorinated biphenyls and polycyclic aromatic hydrocarbons. The obtained results confirmed the existence of pollution with hazardous trace elements in the studied sediments. This study demonstrates DDTs as major organochlorine contaminants in river systems in Serbia. Although use of DDT was officially restricted in Serbia, the result showed evidence of recent inputs of DDT into the river sediments. Pollution prevention and remediation measurements seem essential, especially in areas where we found increased levels of toxic elements and persistent organic pollutants.

Acknowledgment

The study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Projects: ON172001 and III43007).

CONTAMINATION OF FOOD CROPS GROWN ON FLOODED ARABLE SOIL

Biljana Škrbić, Jelena Živančev, Igor Antić, Nataša Đurišić-Mladenović , Maja Buljovčić, Jelena Cvejanov

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Food safety is a major public health concern worldwide. Contamination with potential toxic elements is important, particularly in agricultural production systems and human health. Factors influencing the concentration of potential toxic elements in plants include climate, environmental pollution, nature of the soil on which the plant is grown, and degree of maturity of the plant at the time of harvesting. In this context, the present study was designed to investigate the concentration of 9 of potential toxic elements such as arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), cobalt (Co), nickel (Ni), manganese (Mn) and iron (Fe) in selected crops as well as the potential health risks to humans via consumption of potentially contaminated edible parts of horticultural crops (potato, carrot, celery, parsnip and onion) cultivated in flooded arable area of the northern Serbian province of Vojvodina. Among all analyzed vegetables, the parsnip had the highest average concentrations of Fe (107 mg/kg), Mn (6.98 mg/kg), Cu (1.94 mg/kg) and Ni (0.34 mg/kg). The average concentration of Cd in celery, parsnip and carrot exceeded the maximum allowable levels set by EC/Serbian regulation. Also, average level of Pb (0.54 mg/kg) in carrot samples was almost 5 times higher than the maximum residue level of 0.1 mg/kg set by EC/Serbian regulation. The lowest average concentrations of analyzed elements were found in onion. Additionally, the estimated daily as well as total intakes of the studied elements were far below recommended safe limits, not representing significant risk to Serbian adult population. Total intake per analyzed element was in the following order: Fe>Mn>Cu>Pb>Ni>Cd. Also, total of target hazard quotient (THQ) calculated for each element had the following trend: Fe>Cu>Cd>Pb>Mn>Ni. Potential health risk evaluated as hazard index (HI) was 12 (>1) and it cannot be ignored, particularly, keeping in mind other foodstuffs which were not subject of analysis as well as other potential sources of potential toxic elements in the environment.

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ELEMENTS PATTERNS OF SOIL AND RIVER SEDIMENTS AS A TRACER OF SEDIMENT MIGRATION

Dragana Đorđević[1], Þórunn Pétursdóttir[2], Guðmundur Halldórsson[2], Sanja Sakan[1], Sandra Škrivalj[3], David Christian Finger[4]

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Increasing interest in developing process-based erosion models requires better understanding of the relationships among soil detachment, transportation, and deposition. For study of sediment dynamics in their catchments within chemical approach is already using rare earths elements (REE) contents in soil and sediment and ratios of specific elements in soil and sediments. These methods can carry higher uncertainty because some REE could be missing in the soils and sediments or specific ratios of elements could be similar from area to area in soil and sediments. Idea of STSM of Connecteur COST Action ES1306-34336 is new and includes chemical patterns of elements from soils and river sediments as tracers of sediment migration. For developing methods with chemical patterns of elements in soil and sediments we chose model region of watersheds in south east Iceland. Iceland is the small island on the mid Atlantic ridge, with strong natural catastrophes, such as floods, droughts, landslides, storms and volcanic eruptions that can have devastating impacts on natural and build environment. Rangárvellir area next to Mt Hekla and the glacier Tindfjallajökul has impacted by severe erosion processes but also rich of surface water that play a crucial role in sediment transport processes in the watersheds of the two rivers Eystri-Rangá and Ytri-Rangá. Their sediments consist of various materials originating from volcanoes ash and lava. Difference of contents of various chemical components in sediments and surrounding soil could be bases for identification of erosion processes and watersheds connectivity. River sediment is accumulator of chemical constituents from water in water-sediment interaction, making it as an important material for investigation their migration routes. In order to develop of methods for investigating of sediment migration using their chemical patterns the STSM of Connecteur COST Action ES1306-34336 have been approved. Samples of river sediments and surrounding soils of the Eystri-Rangá and Ytri-Rangá rivers in watersheds of Rangárvellir area as well as primarily volcanic ash from Eyafjallajökull were taken. Sequential extraction of heavy metals and trace elements from collected samples has been applied using the optimized procedure proposed by European Community Bureau of reference (BCR) in the next fractions: 1) soluble in acid – metals that are exchangeable or associated with carbonates; 2) reducible fraction – metals associated with oxides of Fe and Mn; 3) oxidizable fraction – metals associated with organic matter and sulfides and 4) residual fraction – metals strongly associated with the crystalline structure of minerals. Extracted solutions have analyzed by ICP/OES on next elements: Al, As, B, Ba, Be,

Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Li, Mg, Mn, Na, Ni, P, Pb, S, Sb, Si, Sr, V, Zn. Distributions of Si is the same in all investigated samples of soils, river sediments and volcanic ash pointing to the same their geochemical basis. Some elements like Li and partly B exist in the first phase of volcanic ash and river sediments but no in the first phases of soils as if they were already washed from them and adsorbed on the river sediments surfaces. In the first phase of volcanic ash P was found but no exists in the first phase of soil and river sediments. Total content of Bi is found only in silicate matrix while total contents of As is found only in organic/sulphide form in all investigated samples.

Acknowledgment

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PROVENANCE AND POLLUTION STATUS OF RECENT RIVER SEDIMENTS IN SERBIA

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Rivers, which approximately deliver 20 billion tons annually of transported sediment to oceans, play a key role in Earth surface processes, marine sedimentation and biogeochemical cycles in oceans. Trace elements, which are regarded as common environmental pollutants, can have either natural or anthropogenic origin, and it is especially important to distinguish between the two. In order to understand river sediment status it is essential to compare their composition with background values. Pollution status can be more dependent on the use of background values than the index/factor chosen. Most commonly background values used are average composition of continental crust or average composition of shale, statistical methods and natural background samples. The use of average continental crust or shale values in areas where heavy-bearing minerals occur can lead to false anomalies. Statistical techniques can be applied to any region regardless of size, but are only useful when both contaminated and non-contaminated sediments are present. The natural background samples should have following characteristics: minerological-petrogaphical composition has to correspond to composition of analyzed samples, background samples have same or similar sedimentological origin, i.e. alluvial sediments, paleo-drainage area of alluvial systems have to be partly or completely corresponding to the investigated drainage systems and they have to be free of any anthropogenic influence.Sediment samples from water supply wells from Sava River and drill-hole samples from Tisa River were used to evaluate potential heavy metal pollution of recent river sediments from Sava, Danube and Tisa Rivers. The obtained results indicate that Sava sediments show elevated concentrations of heavy metals compared to Danube and Tisa sediments. Furthermore, analyzed sediments from Timok River are free of anthopogenic influence. Their geochemical characteristics are the consequence of geological composition of drainage areas.

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BIO-BASED POLYMERS: STEPS TOWARDS ENVIRONMENTAL RESPONSIBILITY

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The world consumption of plastic materials in agriculture amounts yearly to 6.5 million tons, among which more than 10 % refers to plastic films for soil mulching. The conventional agricultural plastic films used today are low density polyethylene (in some cases high density polyethylene HDPE, or linear low density polyethylene LLDPE), poly(vinyl chloride), polybutylene or copolymers of ethylene with vinyl acetate. A serious negative side effect associated with the steadily growing use of synthetic materials in agriculture concerns the parallel growing disposal problem of thousands of tons of agricultural plastic wastes produced each year. Unfortunately, a large portion of these is left on the field or burnt uncontrollably. These 'disposal options' represent the imminent threat for an irreversible soil contamination.

In the last decades the growing environmental awareness has been prompting the development of a new generation of materials created starting with raw materials from renewable origin. Polysaccharides such as cellulose, pectin, starch, chitosan, alginate, etc. are arousing huge interest as renewable biopolymers potentially exploitable as novel eco-friendly materials. The applicative potential of these water-soluble carbohydrates undoubtedly relies on their structural diversity and wide range of functional properties coupled with low costs and wide availability. However, polysaccharide-based materials usually have poor mechanical and barrier properties when compared to petroleum-based polymers. To enhance overall properties coming from native polysaccharides, we conducted conventional esterification of active pectin groups using chlorides of saturated carboxylic diacids obtained from renewable sources: succinic, adipic, glutaric, sebacic and suberic. Our study indicated that introduction of hydrophobic segments into polysaccharide's chain enhanced the hydrophobic nature of the pectin molecule, giving it a potential to be used in agricultural practice.

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