BOOK OF ABSTRACTS

Natural resources green technology & sustainable development / 2

5th-7th October 2016, Zagreb, Croatia


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BOOK OF ABSTRACTS /2

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ORGA

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Dear coll
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Welcome to the Second international scientific and expert conference "Natural resources, green technology and sustainable development-GREEN/2" organized by Croatian Forest Research Institute and Faculty of Food Technology and Biotechnology, University of Zagreb and supported by Faculty of Forestry, University of Zagreb, Institute for Adriatic crops and karst reclamation and Croatian Society of Biotechnology. The first conference in 2014 was very successful with over 200 participants from 16 countries participated and 130 oral and poster presentations. Our started aim of bringing together scientists and experts from different research backgrounds was more than fulfilled. The enthusiasm and support expressed by participants has prompted us to organize the second conference. We are pleased to host you in Zagreb again.

Leagues friends,

We feel very proud to organize this Conference with the support of International organizations IUFRO, EFI and EBTNA.

The conference is dedicated to challenges and opportunities in productivity & sustainable management of ecosystems, natural sources of functional ingredients, implementation of green technology, biomass and bio-based economy, environment and ecosystem services Researchers from eminent institutions will present their recent accomplishments. The multidisciplinary approach will bring together scientists and experts together to discuss and highlight the latest achievements in science, illustrate new policies, demonstrate innovative techniques and outline sustainability of natural resources.

We use this opportunity to express gratitude to Auspices, International Scientific and Organizing Committee as well as to all of you for your scientific involvement which will certainly contribute to the success of the Conference. Special thanks is addressed to sponsors who enabled the preparation of this event.

Thank you for joining us!

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Dijana Vuletić

CHAIR OF ORGANIZATION COMMITTEE
Ivana Radojčić Redovniković

CHAIR OF SCIENTIFIC COMMITTEE
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CONFERENCE HALL KAPTOL

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8.00-9.00 **Registration**
9.00-9.30 **OPENING CEREMONY**

SESSION A: PRODUCTIVITY & SUSTAINABLE MANAGEMENT OF ECOSYSTEMS

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CHAIRS: D. Vuletić, B. Wolfslehner

09.30-10.15 **Bernhard Wolfslehner:** EU bioeconomy - a forest bioeconomy?, European Forest Institute, EFICEEC-EFISEE Head of Office, Vienna, Austria
10.15-10.30 **Mersudin Avdibegović:** Local comunities as actors of forest policy in selected South-east Euroepan countries: a legislative overview, Faculty of Forestry, University of Sarajevo, Bosnia and Herzegovina
10.30-10.45 **Alessandro Paletto:** Stakeholders' involvement in the Natura 2000 sites management in Italy, Council for Agricultural Research and Economics, Research Centre for Agrobiology and Pedology (CREA-ABP), Italy
10.45-11.00 **Adriano Ciani:** Truffle cultivation: a multifunctional forestry activity as challenge for the sustainable development of the rural areas in temperate zone, Perugia University, Perugia, Italy

11.00-11.30 **COFFEE BREAK**

CONFERENCE HALL GRIČ

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11.00-11.30 **Poster presentations (SESSIONS A&B)**

CONFERENCE HALL KAPTOL

Hotel Panorama

SESSION A: PRODUCTIVITY & SUSTAINABLE MANAGEMENT OF ECOSYSTEMS *- continues*

CHAIRS: D. Vuletić, M. Avdibegović

11.30-11.45 **Adriano Ciani:** Ethnobotany: an innovative opportunity of valorization of edible herbal as example of good practices for the circular economy and social well - being, Perugia University, Perugia, Italy
11.45-12.00 **Svetlana Kabanova:** The Experience of creating a green belt around Astana city, Kazakh Research Institute of Forestry and Agroforestry, Shchuchinsk, Kazakhstan
12.00-12.15 **Alen Berta:** Variability of the basic possession parameters in private-owned forests in Croatia, Pro Silva ltd, Forest management, Zagreb, Croatia
12.15-12.30 **Kristijan Tomljanović:** Big game potentials in regards to meat production, Faculty of Forestry, University of Zagreb, Croatia
12.30-12.45 **Krešimir Krapinec:** Total and palatable fresh plant biomass in Holm Oak and Mana Ash plant association *(Fraxino orni - Quercetum ilicis* H-ić/1956/1958), Faculty of Forestry, University of Zagreb, Croatia
12.45-13.00 **Kasandra-Zorica Ivanić:** Evidence base - protected areas/natura 2000 sites in Dinaric Arc area generating social and economic benefits, World Wildlife Fund for Nature, WWF Adria, Zagreb, Croatia
13.00-13.15 **Stjepan Posavec:** Socioeconomic and arboricultural evaluation of park-forest Jelenovac in Zagreb, Faculty of Forestry, University of Zagreb, Croatia

13.15-14.15 **LUNCH**

Lectures & Parallel sessions

CONFERENCE HALL ZAGREB

Hotel Panorama

SESSION A: PRODUCTIVITY & SUSTAINABLE MANAGEMENT OF ECOSYSTEMS *- continues*

CHAIRS: A. Kern, H. Marjanović

14.00-14.30 **Aniko Kern:** Studying the response of the Central - European vegetation to climate variabilities based on modis and Gimms Data, Department of Geophysics and Space Science, Eötvös Loránd University, Budapest, Hungary
14.30-14.45 **Hrvoje Marjanović:** Forest productivity estimates from modis mod17 (collection 6) for key forest categories in Croatia - How much can we trust them? Croatian Forest Research Institute, Jastrebarsko, Croatia
14.45-15.00 **Elvis Paladinić:** Forest productivity of lowland Pedunculate oak forests of Spačva basin in last 2 decades, Croatian Forest Research Institute, Jastrebarsko, Croatia
15.00-15.15 **Maša Zorana Ostrogović Sever:** Comparison of forest ecosystem productivity estimates based on Biome - BCG MuSo Model and tree-ring data, Croatian Forest Research Institute, Jastrebarsko, Croatia
15.15-15.30 **Ivan Balenović:** Estimation of forest stand attributes using image-based canopy height model, Croatian Forest Research Institute, Jastrebarsko, Croatia

15.30-15.45 **Tamás Misik:** Non-linear height -diameter models for three understorey species in an Oak forest in Hungary, Eszterházy Károly College, Eger, Hungary

15.45-16.00 **Anja Žmegač:** Detection of Canopy gaps with lidar in the mixed Beech-Fir old-growth forest reserve, Faculty of Forestry, University of Zagreb, Croatia

16.00-16.15 **Mislav Anić:** Eddy Covariance measurement of C02 fluxes over Pedunculate Oak forest in Croatia, Croatian Forest Research Institute, Jastrebarsko, Croatia

CONFERENCE HALL SLJEME

Hotel Panorama

SESSION B: FOOD AS NATURAL SOURCES OF FUNCTIONAL INGREDIENTS

CHAIRS: V. Zechner-Krpan, S. Šobajić

14.15-14.45 **Suzana Jukić:** Nutritional quality as part of sustainable food production, Agrokor d.d., Zagreb, Croatia

14.45-15.00 **Siniša Srečec:** Aim and importance of taxonomy, ecology and utilization of Carob tree (*Ceratonia siliqua* L.) and Bay Laurel (*Laurus nobilis* L.) for sustainable development of Croatian coast and islands,Križevci, College of Agriculture Križevci, Croatia

15.00-15.15 **Vesna Zechner-Krpan:** Waste biomass of mushroom Agaricus bisporus as a source of antioxidants, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

15.15-15.45 **Predrag Putnik:** Application of innovative technologies for production of plant extracts as ingredients for functional foods, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

15.30-15.45 **Maja Benković:** Kinetics and thermodynamics of the solid-liquid extraction process of total polyphenols, antioxidants and extraction yield from nettle (*Urtica dioica* L.), Faculty of Food Technology and Biotechnology, Zagreb, Croatia

15.45-16.00 **Djurdjica Čanadi - Knežević:** Elemental analysis in a vriety of agriculutral and forestry contexts, Ansar - analitika, Zagreb, Croatia

16.00-17.00 **COFFEE BREAK**

CONFERENCE HALL GRIČ

Hotel Panorama

16.00-17.00 **Poster presentations (SESSIONS A&B)**
Best poster will be selected in each session

20.00 **GALA DINNER**

CONFERENCE HALL ZAGREB

Hotel Panorama

8.00-9.00 Registration

SESSION C:
GREEN TECHNOLOGY FOR SUSTAINABLE PRODUCTION

SESSION D:
BIOMASS FOR BIO-BASED ECONOMY

CHAIRS: G. Cravotto, M. Brnčić
PLENARY PRESENTATIONS

9.00-9.45 **Giancarlo Cravotto:** How does biomass and bio-based products fit into the circular economy equation?, The University of Turin, Italy

9.45-10.30 **Daniel Kracher:** The role of fungal oxidoreductases in biomass degradation, BOKU, Austria

10.30-10.45 **Aleksandra Sander:** Green solvents in fuel processing, Faculty of Chemical Engineering and Technology, Zagreb, Croatia

10.45 -11.15 **COFFEE BREAK**

CONFERENCE HALL GRIČ

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10.45-11.15 **Poster presentations (SESSIONS C&D)**

CONFERENCE HALL ZAGREB

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SESSION C:
GREEN TECHNOLOGY FOR SUSTAINABLE PRODUCTION - *continues*

CHAIRS: G. Cravotto, M. Brnčić

11.15-11.30 **Nataša Nastić:** Evaluation of antioxidant activity of Aronia (*Aronia melanocarpa*) subcritical water extracts using electrochemical DNA based biosensor and Spectrohotometric methods, Faculty of Technology, University of Novi Sad, Serbia

11.30-12.45 **Anamarija Mitar:** Application of nanosuspension in extractive denitrification and desulfurization of fuels, Faculty of Chemical Engineering and Technology, Zagreb, Croatia

11.45-12.00 **Kristina Radošević:** Ecotoxicology in the service of green technology, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

12.00-12.15 **Marcelina Mazur:** Hydrolytic Dehalogenaton of benzaldehyde-derived y-lactones, Department of Chemistry, Wrocław University of Environmental and Life Sciences, Wrocław, Poland

12.15-12.30 **Igor Tanasić:** Poultry slaughterhouse and meat processing wastewater treatment plant, ASIO, Darda, Croatia

12.30-12.45 **Tea Erjavec Haložan:** Using ecoremediations for protection of hydroelectric power plant accumulation basins from pollution, Company for Applied Ecology, Brezovica pri Ljubljani, Slovenia.

13.00 -14.00 **LUNCH**

Lectures & Parallel sessions

CONFERENCE HALL ZAGREB

Hotel Panorama

SESSION D:
BIOMASS FOR BIO-BASED ECONOMY

CHAIRS: T. Režić, D. Kracher

14.00-14.30 **Tonči Rezić:** Characterisation of hydrodynamic conditions in 3d printedmicroreactor: application in dyes decolonization, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

14.30-14.45 **Mirela Ivančić Šantek:** Lipid production from Lignocellulosic biomass by yeast *Trichosporon oleaginosus*, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

14.45-15.00 **Vlatka Petravić- Tominac:** Potential of corn cobs for production of biofuels and biochemicals, Faculty of Food Technology and Biotechnology, Zagreb, Croatia

15.00-15.15 **Jelena Petrović:** Biosorption of Cu^{2+} from Aqueous Solution by Hydrochar of grape pomace, Institute for Technology of Nuclear and Other Mineral Raw Materials, Belgrade, Serbia

15.15-15.30 **Ivana Plazonić:** The rub resistance of printed ink on papers with variable content of wheat pulp, The Faculty of Graphic Arts, Zagreb, Croatia

CONFERENCE HALL SLJEME

Hotel Panorama

SESSION D:
BIOMASS FOR BIO-BASED ECONOMY

CHAIRS: **D. Vusić, E. Paladinić**

14.00-14.30 **Petar Čurić:** COPRESSWOOD - Formaldehyde free Bio-Based thermosetting resin for wood pressed products, Croatian Chamber of Economy, Croatia

14.30-14.45 **Dinko Vusić:** Results from the first Croatian SRC poplar plantation, Faculty of Forestry, University of Zagreb, Croatia

14.45-15.00 **Isabella De Meo:** Quantifying volume of coarse woody debris in forests: comparison between two sampling methods, Council for Agricultural Research and Economics, Research Centre for Agrobiology and Pedology (CREA-ABP), Firenze, Italy

15.00-15.15 **Marijan Šušnjar:** Fuel consuption and CO_2 emission in timber haulage on different types of roads, Faculty of Forestry, University of Zagreb, Croatia

15.15-15.30 **Branko Hermescec:** Blackwood from softwood to hardwood, Blackwood Technology Co Ltd, Shandong, China

15.30-15.45 **Mohammad Farsi:** The Use of Beverage Storage Pockets (Tetra Pak™) Waste in Wood-Plastic Composites, Islamic Azad University, Sari Branch, Sari, Iran

15.45 -16.30 **COFFEE BREAK**

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Hotel Panorama

15.45-16.30 **Poster presentations (SESSIONS C&D)**
Best poster will be selected in each session

18.00 **Zagreb guided tour**

CONFERENCE HALL ZAGREB

Hotel Panorama

8.00-9.00 Registration

SESSION E:
ENVIRONMENT AND ECOSYSTEM SERVICES

CHAIRS: L. Butorac, N. Potočić
PLENARY PRESENTATIONS

9.00-9.45 **Francois Lefevre:** Challenges in developing an interdisciplinary approach of Mediterranean forest socio-ecological ecosystems, INRA, France

9.45-10.00 **Dijana Vuletić:** Which are the main risks for Mediterranean forests in Croatia and how to response to them, Croatian Forest Research Institute, Croatia

10.00-10.15 **Wathinee Suanpaga:** Plant community characteristics and certain soil properties of beach forest in Andaman coastal area, Thailand, Department of Silviculture, Faculty of Forestry, Kasetsart University, Thailand

10.15-10.30 **Jasnica Medak:** Different aspects of forest damages in mine-polluted Danube-Drava region, Croatian Forest Research Institute, Croatia

10.30-10.45 Nataša Stojić: New emerging pollutants in the soil, Faculty for Environmental Protection, University Educons, Sremska Kamenica, Serbia

10.45-11.15 **COFFEE BREAK**

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10.45-11.15 **POSTER PRESENTATIONS (SESSION E)**
Best poster will be selected in each session

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SESSION E:
ENVIRONMENT AND ECOSYSTEM SERVICES - *continues*

CHAIRS: J. Medak, F. Lefevre

11.15-11.45 **Nenad Potočić**: Nutrition and vitality of forest trees: interrelations and climatic dependencies, Croatian Forest Research Institute, Croatia

11.45-12.00 **Krunoslav Sever:** Photosynthetic activity and vegetative growth of European Pedunculate oak population in drought and post-drought period, Faculty of Forestry, University of Zagreb, Croatia

12.00-12.15 **Damir Ugarković:** Dynamics, hydrological relations and pollution of precipitation and flood waters in forest ecosystem, Faculty of Forestry, University of Zagreb, Croatia

12.15-12.30 **Krunoslav Teslak:** Stand regeneration characteristics of dinaric Beach-Silver fir forests in Gorski Kotar region, Faculty of Forestry, University of Zagreb, Croatia

12.30-12.45 **Sanja Perić:** Stand structure and growth of mixed europeanlarch lime forest culture in Republic of Croatia, Croatian Forest Research Institute, Croatia

12.45-13.30 **LUNCH**

SESSION E:
ENVIRONMENT AND ECOSYSTEM SERVICES
- continues

CHAIRS: M. Gradečki-Poštenjak, D. Matošević

13.30-13.45 **Marko Zebec:** Geometric Morphometric analysis of fruit shape variability in continental populations of ulmus minor mill. Sensu latissimo from Croatia, Faculty of Forestry, University of Zagreb, Croatia

13.45-14.00 **Sanja Novak Agbaba:** Fungal diversity in *Dryocosmus kuriphilus* infected chestnut tree crowns, Croatian Forest Research Institute, Croatia

14.00-14.15 **Ivan Lukić:** Biology and food choice of invasive box tree moth (*Cydalima perspectalis*) in Croatia, Croatian Forest Research Institute, Croatia

14.15-14.30 **Lucija Nuskern:** In search for optimal virus strain for biological control of chestnut blght, Department of Biology, Faculty of Science, University of Zagreb, Croatia

14.30-14.45 **Jelena Kranjec:** New insights on dothistroma needle blight on pine species in Croatia, Faculty of Forestry, University of Zagreb, Croatia

14.45-15.00 **Marno Milotić:** Current Status of ash dieback disease *Hymenoscyphus fraxineus* in Croatia, Faculty of Forestry, University of Zagreb, Croatia

15.00-15.15 **Ivan Lukić:** The development of *Lymantria* dispar larvae on juvenile and mature foliage of *Quercus ilex*, Croatian Forest Research Institute, Croatia

15:15-15.45 **CLOSING REMARKS**


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Poster Presenta

Session A

AP1 **Fran Poštenjak, Karmelo Poštenjak:** Visual tree assessment of trees in recreational and entertainment center "Pionirska dolina" and special evaluation of some VTA methods

AP2 **Branislav Trudić, Saša Orlović, Srđan Stojnić, Dejan Stojanović, Zoran Novčić, Andrej Pilipović:** Forests and forest genetic resources as a potential source of ecosystem services and products - nucleus of a concept in the republic of Serbia forest policy and management

AP3 **Vladimir Novotny, Maja Kerovec, Stjepan Dekanić, Tomislav Nemeš, Anđelina Ivanović:** Floodplain oak forests in protected areas of Croatia: how much, when and why?

AP4 **Georgios Giatas, Georgios Pagonis, Valasia Iakovoglou, Dimitrios Raptis, Dimitrios Emmanouloudis, George Zaimes:** Assessing rural and agricultural riparian area of Greece with the use of GIS and SVAP

AP5 **Mario Ančić, Renata Pernar, Ante Seletković, Jelena Kolić, Silvija Sajković:** Application of unmanned aerial vehicle for mistletoe detection

AP6 **Krunoslav Indir, Vladimir Novotny, Elvis Paladinić, Ivan Balenović:** Standard increment series for common beach *(Fagus sylvatica* L.*)* in evenaged forests of NW Croatia

AP7 **Patrick Huber, Bernhard Wolfslehner, Robert Jandl, Nevenka Bogataj, Dijana Vuletić, Todora Rogelja, Andrej Breznikar, Karolina Horvatinčić, Marta Curman, Silvija Krajter Ostoić:** Good practice examples in vocational education and training and lifelong learning in sustainable forest management in Austria, Croatia and Slovenia

AP8 **Igor Kolar:** Climate Smart Agriculture and Forestry as Part of Solutions to fight global climate change - inclusion of land use in EU's Post-COP21 Policy Framework

AP9 **Lukrecija Butorac, Guillaume Simioni, Goran Jelić, Tamara Jakovljević:** Applying the NOTG model to forest sites in Croatia

Session B

BP1 **Mirella Žanetić, Eva Marija Čurin, Elda Vitanović, Maja Jukić Špika:** Health promoting and sensory properties of Croatian monovarietal virgin olive oils

BP2 **Ivana Tlak Gajger, Nina Bilandžić, Marina Kosanović, Marija Sedak, Bruno Čalopek:** Concentrations of mercury during honeybee wax procession

BP3 **Rebecca Mađarić, Anamarija Šter, Petra Krivak, Lidija Jakobek, Martina Medvidović-Kosanović:** Electrochemical determination of total polyphenols content in appel peel extracts

BP4 **Igor Poljak, Nada Vahčić, Milica Gačić, Marin Ježić, Mirna Ćurković-Perica, Marinela Idžojtić:** Mineral Compostion and heavy metals content of sweet chestnut fruits in five natural populations from central Croatia

BP5 **Sunčica Kocić - Tanackov, Gordana Dimić, Ljiljana Mojović, Aleksandra Djukic-Vuković, Vladimir Tomović, Branislav Šojić, Jelena Pejin:** Antifungal activity of the garlic *(Allium sativum* L.*)* essential oil against aspergillus species isolated from food

BP6 **Vanja Todorović, Milica Zrnčić Ćirić, Bojana Vidović, Sladjana Sobajić:** Influence of heat treatment on antioxidant activity and polyphenolic compounds of cultivated mushrooms

BP7 **Senka Djaković, Jasmina Lapić, Alma Filipović, Arijana Borovnica, Danijela Bursać Kovačević, Verica Dragović-Uzelac:** The use of different extraction methods of bioactive components in Linden flower

BP8 **Suzana Rimac Brnčić, Marija Badanjak Sabolović, Filip Dujmić, Marko Marelja, Mladen Brnčić:** Postdistillation waste as a potential source of bioactive compounds

Session C

CP1 **Ines Cindrić, Nina Popović:** Performance of labaratory-scale constructed wetland for degradation of sodium dodecylbenzensulfonate

CP2 **Jasna Halambek, Ines Cindrić, Marijana Blažić:** Comparative study of basil oil and linalool as green corrosion inhibitors

CP3 **Sandra Budžaki, Goran Miljić, Dragana Jelenić, Ivica Strelec:** Influence of ionic strenght on lipase immobilization on Eupergit cm

CP4 **Anita Slavica, Deni Kostelac, Božidar Šantek, Srđan Novak:** Utilization of maltose in lactic acid production by *Lactobacillus amylovorus* DSM 20531^T

CP5 **Igor Jerković, Marina Rajić, Zvonimir Marijanović, Mate Bilić, Krunoslav Aladić, Stela Jokić:** Supercritical CO_2 extraction and hydrodestillation of *Helichrysum italicum* flowers

CP6 **Antonela Ninčević Grassino, Bojana Brnica, Matea Habuš, Mateja Kobeščak, Patricija Lisica, Sven Karlović, Tomislav Bosiljkov, Damir Ježek:** High hydrostatic pressure extraction of polyphenols from tomato waste

CP7 **Antonela Ninčević Grassino, Senka Djaković, Jasna Halambek, Suzana Rimac Brnčić:** Application of pectin isolated from tomato waste as potential tin corrosion inhibitor

CP8 **Nataša Nastić, Antonio Segura - Carretero, Jesús Lozano - Sánchez, Isabel Borrás-Linares, Jaroslava Švarc - Gajić, Višnja Gaurina Srček, Kristina Radošević, Igor Slivac, Aleksandra Cvetanović:** Extraction of phenolic compounds from comfrey root by green techniques

CP9 **Irena Barukčić, Dražen Časek, Nada Vahčić, Rajka Božanić:** Optimizing of sweet whey ultrafiltration at 25°C and 40°C

CP10 **Kristina Zagajski Kučan, Marko Rogošić, Aleksandra Sander:** Deep eutectic solvent (choline-chloride-glycerol, 1:1.5) as a selective exractant for liquid fuel denitrification

CP11 **Natka Ćurko, Anet Režek Jambrak, Marina Tomašević, Leo Gacin, Karin Kovačević Ganić:** Influence of high power ultrasound as green technology on wine quality

CP12 **Mirjana Ćurlin, Hrvoje Juretić, Goran Smoljanić, Davor Ljubas:** Membrane and reactor system as a contribution to process intensification strategy

CP13 **Aleksandra Gavarić, Milica Ramić, Branimir Pavlić, Jelena Vladić, Robert Radosavljević, Senka Vidović:** Recycling of food factory by-products: subcritical water extraction of Aronia fruit dust

CP14 **Manuela Panić, Kristina Radošević, Natka Ćurko, Marina Cvjetko Bubalo, Karin Kovačević Ganić, Višnja Gaurina Srček, Ivana Radojčić Redovniković:** Isolation of anthocyanins from grape pomace by natural deep eutectic solvents and valorization of its biological activity

CP15 **Kristina Radošević, Iva Čanak, Marina Cvjetko Bubalo, Ksenija Markov, Jadranka Frece, Višnja Gaurina Srček, Ivana Radojčić Redovniković:** Natural deep eutectic solvents - antimicrobial and cytotoxic activity

Session D

DP1 **Antonija Kezerle, Natalija Velić, Hrvoje Pavlović, Darko Velić, Damir Hasenay, Davor Kovačević:** Removal of Congo red from aqueous solution using lignocellulosic biosorbent and solid state fermentation of dye-adsorbed biosorbent

DP2 **Mirela Ivančić Šantek, Lucija Mušak, Vlatka Petravić Tominac, Sunčica Beluhan, Božidar Šantek:** Compositional analysis of lignocellulosic feedstocks

DP3 **Mirela Ivančić Šantek, Ema Zahirović, Sunčica Beluhan, Božidar Šantek:** Production of Cellulases and Hemicellulases by *Trichoderma reesei* on corn cobs

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EP1 **Martina Tijardović, Sanja Perić, Tomislav Dubravac:** Conversion of spruce monocultures to climax sessile oak stands in the central part of the Republic of Croatia

EP2 **Ivan Andrić, Davorin Kajba:** The impact of environmental drivers on *Fraxinus angustifolia* budburst dates

EP3 **Domagoj Trlin, Vinko Paulić, Milan Oršanić, Stjepan Mikac:** Tree rings responses of narrow-leaved ash to climate and hydrological factors

EP4 **Barbara Sladonja, Danijela Poljuha:** Ecosystem services provided by alien invasive plant species

EP5 **Maja Morić, Saša Bogdan, Mladen Ivanković:** Genetic differentiation of pedunculate oak *(Quercus robur* L.*)* seed stands based on height and survival analysis in a field trial "Jastrebarski lugovi"

EP6 **Nana Goginashvili, Nino Memiadze, Maria Akhalkatsi, Irina Tvauri:** Study of rare species and forest sites of high conservation value in Georgia

EP7 **Jelena Kolić, Renata Pernar, Ante Seletković, Ivan Balenović, Mario Ančić:** Comparison of assessment crown damage using analog and digital infrared (CIR) Aerial Photographs

EP8 **Miran Lanšćak, Saša Bogdan, Sanja Mrmić, Nevenka Ćelepirović, Maša Nedanova, Mladen Ivanković:** Occurence of early fructification in pedunculate oak provenance trials

EP9 **Nevenka Ćelepirović, Marija Gradečki-Poštenjak, Sanja Novak Agbaba, Sanja Mrmić, Miran Lanšćak, Ivica Čehulić, Saša Bogdan, Aikaterini Dounavi, Heinz Rennenberg, Mladen Ivanković:** Conservation of genetic resources of forest trees in light of climate changes

EP10 **Marija Gradečki - Poštenjak, Sanja Novak Agbaba, Nevenka Ćelepirović, Monika Karija Vlahović:** Seed quality and health condition of beechnuts of European Beech *(Fagus sylvatica* L.*)*

EP11 **Tamara Marković, Ozren Larva:** Geochemical assessment of the water quality of springs on the northwest slopes of the Ivanščica Mountain EP12 Tamara Jakovljević, Martina Šparica Miko, Ozren Hasan, Slobodan Miko: Determination of carbon and nitrogen In reference soil sample

EP13 **Ivan Pilaš, Jasna Medak, Ivan Medved, Andreja Radović:** Positive responses to recent climate changes in the vegetation activity of the common beech *(Fagus sylvatica* L.*)* ecosystems in Croatia

EP14 **Ivan Medved, Robert Župan, Ivan Pilaš, Jasnica Medak, Marijana Jozić:** Vegetation analysis during the winter using an infrared camera

EP15 **Boris Liović, Tamara Jakovljević, Marija Gradečki - Poštenjak, Ivana Radojčić Redovniković:** The trial plantation of sweet chestnut - Gornja Bačuga

EP16 **Tamara Jakovljević, Nenad Potočić, Ivan Seletković, Ivana Radojčić Redovniković:** Vitality assessment of *Quercus robur* trees: nutritional status, visual and biochemical indicators

EP17 **Lukrecija Butorac, Goran Jelić, Vlado Topić:** Runoff and sediment transport on Mediterranean micro-scale plots with different vegetation cover

EP18 **Boris Miklić:** Impact of canopy on natural regeneration in old stands of black pine *(Pinus nigra Arnold)* in the Vinodol Valley

EP19 **Ivan Seletković, Nenad Potočić, Antun Mikinac:** Assessment of mineral element removal from a pedunculate oak stand by thinning - a quick method

EP20 **Slobodan Miko, Nikolina Ilijanić, Martina Šparica Miko, Ozren Hasan, Dea Brunović, Tena Kolar:** Accumulation of organic carbon in lake and marine sediments during the Holocene on the Eastern Adriatic

EP21 **Fatima Muhamedagić, Mirsad Veladžić, Ania Vuković:** Application of phytoremediation using *Plantago lanceolata* L. for cadmium, nickel and arsenic in controlled conditions

Plenary Talks

EU BIOECONOMY - A FOREST BIOECONOMY?

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KEYWORDS:
circular economy, ecosystem services, forest bioeconomy, forest biomass, green economy

The EU bioeconomy strategy was adapoted in 2012 and is currently under revision. Its five major challenges, (i) Ensuring food security, (ii) managing natural resources sustainably, (ii) reducing dependence on non-renewable resources, (iv) mitigating and adapting to climate change, and (v) creating jobs and maintaining European competitiveness are likely to maintain. All addressed aspects have clear links to the forest-based sector and are perceived to contain a lot of opportunities for the sector to play a substantial role in a bioeconomy.

These assumptions are put to test by elaborating the narrative for a forest bioeconomy and linking the assets and trade-off of forest biomass use and the role of ecosystem services along different stages of the forest-based value chain. Now avenues for measuring and monitoring of a forest bioeconomy are context with recent policy development, market and societal trends. In addition, the relationships to alternative concepts such as the circular economy and the green economy are clarified.

HOW DOES BIOMASS AND BIO-BASED PRODUCTS FIT INTO THE CIRCULAR ECONOMY EQUATION?

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KEYWORDS:
biomass, circular economy, green technologies, lignin extraction

This report aims to highlight best practices on the cascading use of biomass and support to innovation in this domain through the synergy of academia and industry and the use of green enabling technologies. Although natural resources are renewable, there is a very real risk of overexploitation, generation of new wastes and degradation of the many benefits we depend on from nature. Thanks to their favourable environmental footprint, biomass and bio-based products face specific challenges in the context of the circular economy. To stay in line with resource efficiency and green strategies, we need to strike a better balance between by-products, biomaterials and energy uses of biomass, and avoid direct burning of it, this way the overall process will hold true to the so called circular economy equation. The design of a cascade approach to selective biomass extraction and conversion requires a full process design and an economic sustainability analysis to evaluate current state-of-the -art and potential improvements based on new technologies.

Green protocols, process intensification, scale up design, investment costs and environmental impact of new technologies requires multidisciplinary expertises. A smart approach towards biobased and circular economy lies at the interfaces between several research, practice and production disciplines while hearing the viewpoints of chemists, engineers, biologists and biotechnologists. In the last three decades, several attempts with new technologies such as microwaves, ultrasound, hydrodynamic cavitation and ball mills have been reported. Such enabling techniques generate high-energy microenvironments that strongly promote biomass deconstruction in short reaction times and low energy consumption. Lignin extraction from lignocellulosic biomass is the key step to large scale industrial applications and γ-valerolactone (GVL) is an example of biobased green solvent. GVL can be used in a cascade MW-assisted protocol for lignin extraction under non-conventional conditions.

THE ROLE OF FUNGAL OXIDOREDUCTASES IN BIOMASS DEGRADATION

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KEYWORDS:
biofuel, cellulose degradation, lytic polysaccharide monooxygenase, oxidoreductases

Plant biomass represents the largest terrestrial carbohydrate reservoir and is a promising feedstock for the production of hydrocarbons and base chemicals. However, the recalcitrant nature of plant cell walls is the main barrier for their degradation and limits the viability of biorefinery processes. Wood-decay fungi may hold the key to solve this problem. They employ an array of specialized enzymes to convert the recalcitrant polysaccharides in lignocellulose into digestible sugars. The recently discovered copper-dependent lytic polysaccharide monooxygenases (LPMOs) are key players in this process. Their ability to oxidize and degrade highly resistant (crystalline) parts of cellulose boosts the performance of hydrolytic enzymes, which greatly contributes to the cellulolytic capabilities of wooddegrading fungi[1]. Activation of LPMO may occur directly via a specific partner enzyme (cellobiose dehydrogenase)[2] or by other members of the GMC-oxidoreductase family which use secreted or wood-derived phenols to activate LPMO. This allows fungi to specifically adapt to different growth conditions or habitats[3]. These enzyme systems hold great potential to improve the efficiency of commercial enzyme mixtures for biomass processing and biofuel production.

CHALLENGES IN DEVELOPPING AN INTERDISCIPLINARY APPROACH OF MEDITERANEAN FOREST SOCIO-ECOLOGICAL ECOSYSTEMS

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KEYWORDS:
adaptation, mediterranean forests, resilience, social-ecological systems

Mediterranean forests are facing climate change and related uncertainties, which is also challenging the well-being of the human populations. Mediterranean foresters and policy makers are asked to think of, and act for, the future of their forests. In the context of change, a new paradigm for forest management is emerging where short-term and long-term benefits and risks associated with different management options need to be evaluated. Theoretical tools exist that will help to address such complex issues. However, from the theory to the practice is not an easy way. The social-ecological system (SES) approach is an integrated conceptual framework where the ecological structures and processes mutually interplay with social structures and processes. This interdisciplinary framework is particularly suited for agricultural and forestry systems and, in particular, the Mediterranean forests. By considering jointly the social and ecological structures and processes, it allows to address in a comprehensive way the multidimensional aspects of adaptation. On the SES, several notions such as resilience, resistance or recovery can be used across various disciplines to characterize, understand and, ultimately, manage, the responsiveness of the system to environmental changes and disturbance. In particular, the emergence of the concept of resilience in ecology and, later on, exended to the SES helps our views on managing for uncertain future, although this concept has received various definitions which need clarification to avoid misunderstanding. Other notions, like transformability, belong more exclusivey to one field of disciplines and may not always be extended across all disciplines. The first challenge is that putting these concepts in practice is not straightforward and the methodologies need to be clearly defined. The second challenge that I will address is that integrating all these processes, that have different temporal scales and complex interactions, makes it difficult to identify which are the limiting factors and key drivers on which management could act. Based on our experience in the INFORMED project (www6.inra.fr/informed-foresterra_eng) I will underline the analytical potential of these tools, and the challenges in using them. Then I will briefly report on our strategy to overcome these difficulties (when we can).

Session A:

PRODUCTIVITY & SUSTAINABLE MANAGEMENT OF ECOSYSTEMS

LOCAL COMUNITIES AS ACTORS OF FOREST POLICY IN SELECTED SOUTH-EAST EUROEPAN COUNTRIES: A LEGISLATIVE OVERVIEW

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KEYWORDS:
Forest legislation and policy, local communities, South-East European countries

Providing a number of economical benefits and ecosystem services to society, forests in South-east European countries have been legally regulated over the centuries. Due to the unprecedented scale of social, political and economical changes, forest policy and legislation in these countries have changed considerably. Once, being parts of the same country and sharing the common legislative framework for forest management, nowadays Slovenia, Croatia, Serbia and Bosnia-Herzegovina have different social and economical realities. The complexity of international forest policy processes brought the new modes of forest management, in which the role of national forest authorities will not be totally excluded but will be significantly changed. In this context, the new political environment have mobilised new interest groups at the national level and some of them, such as local communities, become important actors of forest policy. This paper deals with the role of local communities in development of new forest legislation, particularly the distribution of economical benefits from public forest management and legally prescribed instruments to strengthen the position of local communities in forest management and planning. Through comparative overview of national forest legislation in Slovenia, Croatia, Serbia and Bosnia-Herzegovina, the paper explores the evolution of relations between public forest administration, as traditionally the strongest actor of forest policy in these countries and forest-dependent communities, as an emerging and powerful interest group. Several impacts on environment, social development and economical growth of this "power redistribution" process, at the national and local level, will be also analyzed. Comparative analysis between four countries, in terms of demands and legally-prescribed role of local communities as new forest policy actors, offers an interesting insight in general development and trends of forest legislation and forest policy in the region.

STAKEHOLDERS' INVOLVEMENT IN THE NATURA 2000 SITES MANAGEMENT IN ITALY

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KEYWORDS:
conflicts, Italy, public participation, questionnaire survey, stakeholders

Natura 2000 network includes the sites of community importance (SCIs) identified by the Directive 92/43/EEC ("Habitats Directive") and the special protection areas (SPAs) defined by the Directive 79/409/EEC ("Birds Directive"). This network of protected areas can be considered the cornerstone of EU nature conservation policy, aimed at ensuring the long-term protection of endangered species in their natural habitats. In Italy - due to the various geographical and climatic contexts of Italian peninsula - Natura 2000 network plays a key role in maintaining an extensive range of habitats and wildlife species. After the institution of Natura 2000 network the area devoted to nature conservation increased from 11% of to 20% and many areas rich in biodiversity have been included in the network (2,288 SCIs for an area of 45,309 km² and 597 SPAs that cover 43,777 km²). The Habitats Directive was transposed in the Italian legislation with the Decree n°357 (8th September 1997). This Decree ratified the processes of Natura 2000 network realization, and delegated to the Regions and Autonomous Provinces the implementation of the Directive. Each Region adopted an own strategy for the development of Natura 2000 site management plans, the monitoring and verification of the progress, and the stakeholders' involvement in the decision-making process at local scale. Consequently, the network implementation was very different from region to region. Starting from these considerations, the aim of the study is to investigate the participatory process adopted in Natura 2000 sites management in Italy, highlighting the main strengths and weaknesses. The participatory process was analyzed through a qualitative survey, based on the opinions of the different stakeholders involved in the process. Data were collected by administering a semi-structured questionnaire to 50 stakeholders representing the four main groups of interests at stake during the process: public administrations, academia and research institutes, environmental NGOs and landowners. Results show that nature conservation is considered the most important human activity in Natura 2000 sites, followed by environmental education and forestry practices. Information also revealed that participatory process was conducted with different tools and at various level of involvement from region to region and in some cases in single protected site. In the majority of cases, during the implementation process, decisions were taken by authority (40% of cases) followed by minority decision (28%) and consensus decision (23%). In addition, respondents indicated a high percentage of conflicts (85% of respondents) between groups of interest. Many of the conflicts raised between hunters and environmental associations and between forest owners and environmental associations.

THE EXPERIENCE OF CREATING A GREEN BELT AROUND ASTANA CITY

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KEYWORDS:
agroforestry plantings, construction of forest belt, forestry

The aim of the work is expansion of the range of tree and shrub species, including exotic species, in forest-steppe zone of Northern Kazakhstan in suburban forests around Astana. The largest area of lands (55%) intended for establishing the green belt around the capital of Kazakhstan is accounted for by plough-lands, grass swards, and hay-makings, i.e. not forest lands. So the main object of forest management is cultivation and formation of steady forest stands having high aesthetic, sanitary and hygienic qualities. It was found that 27.4% of artificial plantings in the green belt of Astana have good condition; 45.1% have satisfactory condition, and 27.5% have unsatisfactory condition. The main reasons for forestry waste and unsatisfactory condition of forest plantations are in fraction of agricultural technique of planting, deficiency of watering, damage by pets, untimely and unsatisfactory taking silvicultural measures, and wrong selection of species according to soil conditions.

In the range of tree and shrub species in the green zone dominate *Populus balsamifera, Salix acutifolia, Ulmus pumila, Acer negundo, Acer tataricum, Caragana arborescens, Fraxinus excelsior, Betula pendula*. Ball-rooted and bare-rooted seedlings *(Abies balsamea* (L.) Mill.), *Picea Engelmanni* Engelm., *Picea pungens* Engelm., *Picea mariana* Mill., *Picea obovata* Lebed., *Pinus sylvestris* L., *Abies sibirica* Lebed., *Quercus robur* L., *Larix sibirica* Lebed) were planted experimentally to expand the range of trees. The monitoring of growth of seedlings allowed us to draw a conclusion that ball-rooted seedlings had the best growth and capacity for survival. Among the bare-rooted seedlings the best capacity for survival was shown by *Quercus robur* L. (88.2%) and *Picea obovata* Lebed (70.0%), but every year oak slightly freezes because of late spring frosts.

To increase the safety of artificial plantings proposed to increase the duration of watering of seedlings by seasons and years. To receive standard seedlings it is necessary to optimize the agricultural techniques of cultivation of planting material in own garden nurseries and produce forest plantations with own seeds or seeds collected in other regions according to seed regional assignment. One of the promising tree species for second planting of forest plantations in the conditions of the green belt of Astana is spruce because it is most adapted for conditions of Northern Kazakhstan. On solonetz soils as amelioration can be applied to the drainage of rubble or sand and to plant *Elaeagnus angustifolia, Betula pendula, Acer negundo, Caragana arborescens*.

ETHNOBOTANY: AN INNOVATIVE OPPORTUNITY OF VALORIZATION OF EDIBLE HERBAL AS EXAMPLE OF GOOD PRACTICES FOR THE CIRCULAR ECONOMY AND SOCIAL WELL –BEING

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KEYWORDS:
biodiversity, circular economy, ecotuypes, edible herbal, ethnobotany, farmer knowledge, natural resources, sustainable development, territory management

The objectives for sustainable development for 2015-2030 give propulsion to the Age of Sustainable Development and strengthening of the Circular Economy. This paper focuses on the recovery of ancient customs and traditions of control, collection and utilization of food for traditional and / or healthful of wild plant species in central Italy. This in the various agro-ecosystems rural development relating to fields planted with pasture or pertaining surfaces of companies or other more or less populated infrastructure and marginal areas of unproductive hilly terrain. The interest in ethnobotany has increased in recent years, saving these "knowledge" in fact, it also saves the cultural identity. Each farmer has a complex "knowledge" in respect of plants, "knowing" that is so important that some have called the farmers, who still retain them, "living treasures" or "witnesses". The use of wild plants in the kitchen has always been deeply rooted in Italy especially in the inland areas and in rural areas, although in many cases are only the preserve by the only older people.

The paper analyzes in particular the more ten years of experience in the Umbria Region(Italy) in which the research project, experiments and tests it is deployed by checking the organoleptic characteristics, nutritional and health benefits of the most widespread ecotypes. A major reason is that man, in today's busy life, is not it time for the knowledge of the products of the earth that gives us the nature and prefers to feed on the food of so-called fast food cuisine. In recent years, however, the situation is improving because there is increasing interest for the consumption of different food plants, both in liquid preparations either salad or "green contours" and we can definitely say that the edible wild plants will have a role important feeding in the future. Configuring a wonderful example of fusion between tradition and innovation, organizational activities and full circular character life where the 3R (reduce, reuse, recycle) make possible the recovery of lifestyles especially in power directed towards a healthy social welfare in terms psychophysical.

The experience of the project has the character of repeatability and retraceability and represents a way of further transformation of the weaknesses into strengths of the rural areas of each country including Croatia and an innovative interlocking possible sustainable management and promotion of the territory.

TRUFFLE CULTIVATION: A MULTIFUNCTIONAL FORESTRY ACTIVITY AS CHALLENGE FOR THE SUSTAINABLE DEVELOPMENT OF THE RURAL AREAS IN TEMPERATE ZONE

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KEYWORDS:
forestry, green economy, land management, multifunctionality, sustainable development strategy, truffle production, well–being

Truffles are the finest and most expensive symbiotic fungi actively marketed all over the world. Spread throughout the Mediterranean basin and beyond, each truffle species has its own autecology as a particular growing niche that is currently threatened by the change in forest management, the abandonment of the countryside, the excessive truffle harvesting and the climate change.

The gradual change of development strategies nowadays entrusts all of us a strong duty after the approved document, on 25th September 2015, by the UNGASS "Transforming our world: the 2030 Agenda for Sustainable Development" that deep involves, all the world, in the implementation of the seventeenth SDG's 2015-2030. In recent years inside at two Industrial Revolutions (III^ and IV^) two possible pathways have become popular: the Green Economy and the Bio-Economy. The Bio-Economy introduces new paradigms in the production processes related to renewable natural resources. In view of the new trends requested by the sustainable development strategies in agriculture and forestry, this paper discusses the ecological requirements of the main species of truffles and their forest management in Mediterranean Areas, highlighting the legislative and professional requirements in order to facilitate the protection and conservation of this precious heritage. In this context also the forestry management of truffle natural productive sites as well as truffle cultivation should take on the role of public service linked to productivity but also to protect the value of bequest and the existence of truffle ecosystems.

The authors propose and show with data the multifunctional approach of the truffle cultivation, that in this role contributes to the total economic value of public forest commodities. They assign a key role to sustainable management in mountain areas, soil conservation, territory promotion, protection of biodiversity and natural habitats, water regulation and the production capacity of the soil in order to promote food security, development of disadvantaged economies and poverty reduction. In this sense, the paper stresses like forest management of truffle productive sites, truffle cultivation and/or reforestation using truffle plants can give to the truffle a real role to enhance and strengthen the common good in suited environments. The truffle can be a concrete example where a coherent forest and land management, combining innovation with tradition, can achieve multiple objectives that the strategy of sustainable development requires us from the economic, social, ethical and moral point of view, to contribute at the end to the well-being and happiness of the society.

VARIABILITY OF THE BASIC POSSESSION PARAMETERS IN PRIVATE-OWNED FORESTS IN CROATIA

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KEYWORDS:
cadastral plots, forest estates, forest ratio, private forest landowners

If we strive towards sustainable management, forest management is a challenge because it requires expertise, timeliness and moderation. This also means that this type of management needs to be in line with the forest stand capability. In order to achieve influence and impact, these terms have to be implemented on the stand level, not the cadastral plot level that is the most prevalent management system in Croatian private-owned forests. In this case, even if the landowner is well versed in proper management, he does not have influence towards sustainable management of the area if neighbouring landowner has different management vision and needs.

This management system leads towards uneven quality and age, often resulting in stand degradation. This is especially pronounced when there are many small plots/estates nearby, each with multiple owners.

In this paper, the following parameters will be presented; the level of the forest plots/estates size degradation, number of the co-owners, portion of the private-owned forest and the portion of the overgrown agriculture land (by cadastral noted landuse) in the private-owned forest management plans (FMP). The sample data represents almost 16 % of the Croatian private-owned forest area. Parameters are calculated on cadastral municipality (CM) level and then their variability is analysed on regions level.

The results have shown that: Dalmatia has the lowest ratio of overgrown agricultural land, Gorski Kotar and Lika have lower ratio of private owned forest, whilst Istria and Kvarner have the highest average number of co-owners in possession sheets. Slavonia has lower or the lowest values regarding other regions for average area of the estate in CM's, number of co-owners and ratio of private-owned forests in CM's. Central Croatia has the lowest numbers of co-owners and average size of the cadastral plots in FMP's.

By analysing these results we can conclude that an average forest-landowner in Croatia possesses from 2 (Slavonia) to 9 (Dalmatia) forest plots, often having one more co-owner. Furthermore, every 3rd plot is overgrown agricultural land (in Dalmatia, every 20th). Also, having in mind that plots in landowner's possession are often far away from each other, it is obvious that sustainable forest management is not possible for individual small forest landowner.

This can be solved by intense and constant effort from the government and Advisory Agency trough establishing efficient subsidies and support in management and grouping. Hopefully, this would induce forest landowner's interest and willingness to associate with other forest landowners.

BIG GAME POTENTIALS IN REGARDS TO MEAT PRODUCTION

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exploitation, game, management, meat, wildlife

Wild game has always been used in human consumption. With the development of gatherer society the first activity was wild animal hunting, and later followed their domestication, crossbreeding and cultivation with the purpose of producing meat. Lately, much attention is paid to food being produced in an ecological manner without using blends, preparations and other artificially produced nourishments that encourage growth and breeding of animals in order to get as large quantities of meat in the shortest amount of time and in the smallest territory. No matter whether it is about management with the purpose of meat production or for the purpose of selling cull and trophies, the working principle and obtaining meat have changed over time with the development of new techniques and technologies. During time hunting weapons gave become more precise, and ammunition more lethal. Animal killing has become almost instant, and with it the influential stress levels smaller. On Croatian territory wild game meat exploitation is similar to one in Europe. It is less than one kilogram per capita in one year. Usage of wild game meat is greatly directed within the families of hunters, while the wild game meat market is reduced to very poor and sporadic offers in retails chains. In Republic of Croatia most meat is produced from wild boar (1 570 t), followed by roe meat (408 t) and by common deer (335 t). Meat production according to LPP for each individual species is on average the highest for wild boar and it is 1,28 kg/ha, followed by common deer 0,73 kg/ha and roe deer 0,31kg/ha. The amount of meat that is being produces from three researched species of big game on average amounts to 0,5 kg per capita. According to the number of registered hunters it turns out that annual production of meat from the three researched species amounts to 36,8 kg/hunter, which is almost more than the half year need that on the level of Croatia amounts to 60 kg/capita, and more than third of the recommended annual need of 85 kg/capita. Financially speaking, annual production amounts to little over 60 million HRK and represents contribution to the economy. The determined problem, not only in Croatia but also in most European countries, is the insufficiently widespread market and still a pretty much closed circle of people that consume this meat.

TOTAL AND PALATABLE FRESH PLANT BIOMASS IN HOLM OAK AND MANA ASH PLANT ASSOCIATION (*Fraxino orni – Quercetum ilicis* H-ić/1956/1958)

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KEYWORDS:
biomass, browsing, forage, Mediterranean, wild ruminants

Recent Mediterranean landscape has developed under the influence of three basic factors, which make it different from other European landscapes. These factors are climate, fires and intensive human influence, the latter most pronounced through cattle pasturage during the last 5 000 years. Since the end of the 20th century, in certain parts of Mediterannean basin cattle numbers have been in decline and its place has spontaneously been taken by wild ruminants. Therefore, research of interaction game-habitat represents the foundation of wild ruminants management of this area (as well as the livestock). For this reason, the research on total and palatable fresh plant biomass in holm oak and mana ash plant association was conducted in order to estimate capacity for particular game species. The research has shown that plant biomass (up to 2 meters above the ground), as well as woody species dominance in total biomass changes significantly depending on the part of forest such as young growth, stand boundary and central part of a stand. Biomass foundation is made of three plant species: laurustinus (*Viburnum tinus*), strawberry tree (*Arbutus unedo*) and holm oak (*Quercus ilex*). In general, this vegetation habitat produces 1 482 kg/ha per year, of wich 1 288 kg/ha is palatable.

EVIDENCE BASE - PROTECTED AREAS/NATURA 2000 SITES IN DINARIC ARC AREA GENERATING SOCIAL AND ECONOMIC BENEFITS

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KEYWORDS:
Dinaric Arc, ecosystem services, protected areas, socio-economic benefits, Western Balkans

The main goal of WWF Adria is protection of the natural environment, biodiversity and ecological processes in the Dinaric Arc area (Albania, Bosnia and Herzegovina, Croatia, Kosovo, FYR Macedonia, Montenegro, Serbia and Slovenia). The purpose of the programme "Protected Areas for Nature and People" (PA4NP), implemented by WWF Adria is sustainable use of natural resources in the Dinaric Arc region as a foundation for the socio-economic development. An interactive evidence base will be developed to illustrate various benefits offered by protected areas.

Main goal of the evidence base is to: provide greater interest, better investments and better conservation of natural values through the display of socio-economic values of protected areas/Natura 2000 sites and natural resources in the region. This will be accomplished by conveying scientific evidence into key messages to decision-makers, business sector and all stakeholders, with the aim of having them use such messages for better protected areas management, improvement of status of nature in the region and present the link between the preserved nature and sustainable development.
The database, an integral part of evidence base, consists of a vast number of scientific articles. The policy team of PA4NP programme will use the evidence base through national advocacy plans to effect decision makers and key influencers to improve environmental policies.

WWF team will cooperate with potential contributors to the evidence base, and build partnerships for joint work in order to apply scientific research in to practice, and to use the evidence for lobbying and advocacy on relevant environmental issues in the region in various ministries. The potential contributors are expert and scientific institutions and their students, institutes for nature protection, protected area staff, civil society organisations operating in eight program countries. The needs of contributors and partners will be incorporated into the evidence base. Protected Area Benefit Assessments data obtained with in discussion with over 1300 people from 58 Protected Areas in eight countries will be complemented by evidence from other organisations and partners.

Findings will be presented through a range of communications tools tailored to audiences with different level of interest, from readily accessible, succinct case studies in forms of infographics, visually attractive graphs, and brochures to comprehensive reports. We will monitor the use and perceived relevance and accessibility as to make sure that it contributes to the outcomes of PA4NP project.

SOCIOECONOMIC AND ARBORICULTURAL EVALUATION OF PARK–FOREST JELENOVAC IN ZAGREB

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KEYWORDS:
evaluation, tending costs, urban forests benefits, urban planning

Urban forest represents a forest covered area nearby an urban area. Urban forests in City of Zagreb are situated on 22 separate locations and cover 395,08 ha, distributed mostly over northern parts of the city at the lowest south, southwest and south east slopes of Medvednica mountain. They are surrounded with urban settlements and family houses, making them under pressure to decrease the area which considerably influences their functioning. Also, they are an integral part of Zagreb's green areas and represent attractive places for both citizens and visitors.

The goals of the General urban plan in Zagreb (GUP) are protection of historic and natural values and continuous registration and restoration of endangered historical and other city identities like morphological diversity and park forests.
City park forests could be modified into park areas, with management that preserves their natural forest structure and with equipment in favour of recreational facilities as one of the non-wood forest functions. The plan for the park-forest area management is defined within city bodies' responsible for forest management and protection of specific nature protected areas in city area.

Basic characteristics of arbour species and estimated visual characteristics of Park Forest Jelenovac were determined using the field measurements. Sample consist 610 selected trees of different species (quercus robur, ash, common beech) distributed over the research area. Using the cost benefit analysis method, tending and rehabilitation costs needed for the stand management have been used and estimation has been made of ecological and social benefits from the stand production.
Analysis was conducted in accordance with the group of trees defined within same species.

Urban forests costs consist of tree plants costs, human work, maintenance costs etc. Benefits are non-wood forest functions, especially recreational, health, touristic and aesthetic components.

Results show positive correlation between costs and benefits offered by urban forest and analysed tree sample. Conclusion confirms that investment in urban forests management besides socioecological has also the economic justification.

STUDYING THE RESPONSE OF THE CENTRAL-EUROPEAN VEGETATION TO CLIMATE VARIABILITIES BASED ON MODIS AND GIMMS DATA

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KEYWORDS:
climate variability, MODIS, NDVI, remote sensing, vegetation

Vegetation phenology and productivity is strongly linked with the actual weather conditions, and in the long term with the local climate. Our current understanding on the environmental control on phenology and vegetation dynamics is incomplete. Causes of the interannual variability and productivity are not well understood as well. Satellite remote sensing provides a feasible way to monitor and study the changes of vegetation functioning in general and to understand its relationship with the climate fluctuations.

In the present study remotely sensed vegetation indices and other vegetation related characteristics were used to characterize vegetation activity and its interannual variability in Central Europe. The research was primary based on the latest version (Collection 6) Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI) products calculated from measurements of the MODerate resolution Imaging Spectroradiometer (MODIS) sensor onboard the National Aeronautics and Space Administration (NASA) Terra and Aqua satellites and on the NDVI dataset of the Global Inventory Modeling and Mapping Studies (GIMMS). However, other remotely sensed MODIS products were also used, such as the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Leaf Area Index (LAI), Gross Primary Production (GPP) and Net Primary Production (NPP). We applied the climatological FORESEE (Open Database for Climate Change Related Impact Studies in Central Europe) meteorological database to investigate the effect of precipitation and temperature on the vegetation of the Carpathian Basin, especially in view of forests, croplands and grasslands. The applied MODIS products cover the 2000-2014 time period, while the GIMMS dataset provides the longest data series, starting from July of 1981.

FOREST PRODUCTIVITY ESTIMATES FROM MODIS MOD17 (COLLECTION 6) FOR KEY FOREST CATEGORIES IN CROATIA – HOW MUCH CAN WE TRUST THEM?

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KEYWORDS:
eddy covariance, GPP, NPP, pedunculate oak, remote sensing

Forests have significant role in climate regulation, locally dampen extremes in weather, provide various other environmental services, as well as resources needed for the economy. Anthropogenic activity and consequently the climate change affects the productivity of forests in opposing ways – positive (atmospheric CO_2 enrichment, nitrogen deposition, elongation of growing season due to global warming) and negative (higher frequency of weather extremes and drought in particular, invasive species, new diseases etc.). In recent years the rate of change is visibly accelerating. Hence, envisaging the effects it will have on the forest productivity present a great challenge for forest monitoring and management. Remote sensing presents one of the most viable tools in finding solutions to these problems.

The main goal of our work is to evaluate the currently available productivity assessments from remote sensing for monitoring different forest types in Croatia. In our work we used productivity estimated with MODIS sensor on board NASA's Terra satellite, namely the MOD17 GPP and NPP products. NASA recently issued a new Collection 6 (C6) of the MOD17 products, where the sensor degradation problem has been addressed which was present in the previous Collection's 5.5 (C5.5) products. We investigate the improvement in the productivity estimates in the new C6 against GPP and NPP estimates from eddy covariance flux measurements at Pedunculate oak forest in Jastrebarsko which serves as ground truth. Secondly, we investigate how the outlook for forest productivity changes from C5.5 to C6 for different forest ecosystems dominated by four main tree species in Croatia (*Abies alba, Fagus sylvatica, Quercus petrea, Quercus robur*).

Our results indicate that new C6 has reduced bias in GPP and NPP compared to C5.5 and to EC flux measurements, however there was no evidence of the improvement in precision. Annual GPP and NPP estimates for all forests categories grouped by different dominant tree species is higher in C6 than in C5.5 but unequally. We found that some of the Pedunculate oak forests (Spačva river basin) have been categorized as mixed broadleaved and evergreen forest by the MODIS Land Cover Type Product (MCD12Q1) that is used in obtaining MOD17. Our findings indicate that, although remote sensing is indispensable for monitoring productivity of ecosystems, a due caution is needed in its application at the local scale. Further research is needed that would help improvement of the MCD12Q1 as well as in making refinements of Biome Properties Lookup Tables (BPLUT).

FOREST PRODUCTIVITY OF LOWLAND PEDUNCULATE OAK FORESTS OF SPAČVA BASIN IN LAST 2 DECADES

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KEYWORDS:
climate, management activities, Quercus robur L., tree cores, tree-ring width

Lowland forests of pedunculate oak (*Quercus robur* L.) are economically most valuable forests in Croatia, but at the same time they are under great anthropogenic pressure. Considering economic value, ecological importance, climate variations, and already existing extensive research infrastructure of Croatian Science Foundation project EFFEctivity (HRZZ-11-2013-2492), this paper is primarily focused on lowland oak forests productivity issues of large forest complex of pedunculate oak of Spacva Basin.

Forest productivity is monitored and analysed considering site-specific conditions, and with adequate temporal and spatial resolution. Although assessing forest productivity with classical forestry method (tree cores) is slow, labour intensive and expensive but reliable, it is also essential for validation of remote sensing and process-based modelling productivity estimates.

Field surveys were conducted from spring 2015 to spring 2016. Tree cores were sampled from 77 sample plots distributed across pedunculate oak forest communities forming Spačva forest complex. The radius of the circular plots varied depending on the forest age (chronosequence method) and tree diameter, ranging from 2-17m. The cores were taken from dominant and co-dominant trees, and were prepared using standard dendrochronological methods. Tree-ring widths were measured to the nearest 0.001 mm using CooRecorder software. These ring widths were used to facilitate assessment of inter annual variability of productivity, based on and analysed in combination with existing spatially explicit data on forest, to classify areas of lowland oak forests according to their productivity. Variability of inter-annual productivity of trees with respect to climate data as well as trends were analysed. The past management activities with their impact on tree-ring width were observed and analysed, too.
Preliminary results indicate the influence of climate and management activities in the past on variation of the tree-ring widths of pedunculate oak and other co-dominant tree species. Based on the results of analysis it is possible to identify: trees growing in suboptimal environmental conditions, forest areas with different trends in productivity (e.g. indicator for forest succession); spatio-temporal variability of annual forest productivity (e.g. indicator of sensitivity to climate extremes).

COMPARISON OF FOREST ECOSYSTEM PRODUCTIVITY ESTIMATES BASED ON BIOME-BGCMuSo MODEL AND TREE-RING DATA

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KEYWORDS:
Biome-BGCMuSo, forest productivity, model parameterization, NPP, Pedunculate oak

Sustainable forest ecosystem productivity can be considered as a measure of forest vitality. Therefore, information on trends in productivity is of great importance for forest management. Sustainability of productivity of existing forests is linked with increased uncertainty due to climate change and various human and/or natural disturbances. Monitoring of forest productivity through field measurements represents an important source of information for forest management. However, monitoring can only provide information about the past growth, while estimates of future growth require models. Assuming that the current climate change affects the growing conditions, usage of mechanistic models building on the assumption that future growth can be estimated based on growth in the past, are not adequate. Process-based ecosystem models are necessary in the assessment of possible pathways that the forest ecosystem might take under changing conditions (environmental or management, or both).
Aim of our research is to validate modelling results of forest ecosystem productivity (NPP) from Biome-BGCMuSo model with observed productivity estimated from extensive dataset of tree-rings. The research was conducted in two distinct forest complexes of managed Pedunculate oak, namely Pokupsko basin and Spačva basin.

First we parameterized BIOME-BGCMuSo model at a local level using eddy-covariance (EC) data from Jastrebarsko EC site. Parametrized model was used for the assessment of productivity on a larger scale. Results of NPP assessment with Biome-BGCMuSo are compared with NPP estimated from tree-ring data taken from trees on over 100 plots in both forest complexes.

ESTIMATION OF FOREST STAND ATTRIBUTES USING IMAGE-BASED CANOPY HEIGHT MODEL

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KEYWORDS:
aerial images, canopy height model, digital photogrammetry, forest inventory, image matching

The aim of this research was to investigate the applicability of canopy height models (CHMs) derived from digital aerial images for estimation of the main forest stand attributes (mean diameter, mean height, stand density, basal area, volume) of even-aged pedunculate oak forests. The research was conducted in the management unit Topolovac in Spačva basin (eastern Croatia), one of the largest coherent complex of lowland pedunculate oak forests in Europe.

A CHM of the research area was generated by subtracting ground from surface elevations, i.e., by subtracting a digital terrain model (DTM) from corresponding digital surface model (DSM). For the DTM generation, a national digital terrain data were used. First, a triangular irregular network was created from the digital terrain data, which was then converted through linear interpolation into a raster DTM of 1 m grid size. For DSM generation, the colour infrared digital stereo aerial images collected as a part of the regular national survey in 2011 were used. A DSM of 1m grid size was generated using Dense DTM image matching algorithm (PHOTOMOD 5.24 software).
In order to develop models for estimation of forest stand attributes, the data from field surveys conducted within regular forest inventory in 2011 were used as dependent variables, whereas metrics extracted from raster CHM were used as independent variables with addition of several variables from forest management plan (stand age, soil type, site class). A large number of potential independent variables were extracted from raster CHM, and only variables with the strongest correlation with field stand data were used in statistical modelling (multivariate linear regression). In total, 60 stands were used for models development, while 30 stands were used for models validation.
The validation of stand-level models resulted with the following R2 values between observed and predicted estimates: 0.86, 0.91, 0.76, 0.71 and 0.80 for mean diameter, mean height, stand density, basal area and volume, respectively. The obtained results indicate that CHM derived from digital aerial images and national digital terrain data has potential for operational use in forest inventory of lowland pedunculate oak forests.

NON-LINEAR HEIGHT–DIAMETER MODELS FOR THREE UNDERSTOREY SPECIES IN AN OAK FOREST IN HUNGARY

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KEYWORDS:
Acer campestre,
growth model,
residual standard error,
shrub layer,
size

Information about the diameter and the height of woody species is fundamental to developing growth and yield models in forest stands. Equations for the height-diameter relationship for some woody species of the understorey in a temperate deciduous forest have not been extensively reported in published studies. Ten non-linear height-diameter functions were fitted and evaluated for the site. The data set consisted of 957 selected individuals of three dominant woody species (*Acer campestre* L., *Acer tataricum* L., and *Cornus mas* L.), and represented a wide range of woody species sizes. The aims of the present study were (1) to evaluate ten height-diameter functions using a long-term data set covering studied woody species; to identify the most appropriate height-diameter functions for the three woody species; and (3) to confirm by the long-term data obtained possible changes on the most fitted height-diameter functions for studied species results following canopy decline. The average coefficient of determination (R^2) was about 0.68 for the three estimated species. For the two-parameter non-linear models, with the exceptions of the parameters in function "Larson 1986" for *A. campestre* in 1972, all the t-statistics for the parameters of the functions were significant at the $p = 0.05$ level. Residual standard error (RSE) results of the two-parameter functions showed that the "Wykoff et al. 1982" and "Bates and Watts 1980-Ratkowsky 1990" functions had lower RSE values in 1972. After oak decline the "Larson 1986" and "Bates and Watts 1980-Ratkowsky 1990" functions had lower values. With the exceptions of the parameter in functions "Curtis 1967; Prodan 1968" and "Sibbesen 1981" for the three woody species (excluding *A. campestre* in 1982–2012 and C. mas in 1972) and function "Ratkowsky 1990" for every species in 1972, all the t-statistics for the parameters of the functions in the three-parameter nonlinear models are significant at $p = 0.05$ level. The RSE data for the three-parameter functions showed that the "Pearl and Reed 1920" function had fitted RSE values at the start of the long-term study. After canopy decline function, the "Ratkowsky 1990" function RSE value was lowest for *A. campestre* and *C. mas*. "Pearl and Reed 1920" was the best-fitted function for *A. tataricum*. Height-diameter equations increase our knowledge about the growth of these species, which will enable us to improve management planning in oak forests.

DETECTION OF CANOPY GAPS WITH LIDAR IN THE MIXED BEECH-FIR OLD-GROWTH FOREST RESERVE

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KEYWORDS:
gap size distribution, geomorphological factors, LiDAR, old-growth forest, power law

The aims of this research are (1) analysis of the Canopy Gaps (CG) pattern in the mixed beech-fir old-growth forest reserve using LiDAR (Light Detection and Ranging) survey and (2) analysis of the impact of geomorphologic factors (obtained from digital terrain model) on the Canopy Gaps fraction and size distribution. Using LiDAR data shows up as an accurate, detailed and efficient way to record and measure Canopy Gaps inside the old-growth forest reserve. Results of this research show that Canopy Gaps size, density and area increase with higher elevation, higher terrain slope, northern aspect and higher Wind exposure index which is mainly linked to the direct influence of dominant wind and canopy height. By combining LiDAR technology with field surveys (especially tree rings based method) we can get useful information about spatial and temporal Canopy Gaps dynamics in old-growth forest reserves. Results of this research can be practically applied in the all-day Close to nature forest management.

EDDY COVARIANCE MEASUREMENT OF CO_2 FLUXES OVER PEDUNCULATE OAK FOREST IN CROATIA

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KEYWORDS:
carbon dioxide, dendrometer bands, eddy covariance, pedunculate oak

Water vapour and carbon dioxide are the main atmospheric constituents which are controlling the Earth's climate. Increase in atmospheric content of carbon dioxide is considered as one of the main drivers of climate changes on Earth. Forests play significant role in regulation of climate because they absorb CO_2 from the atmosphere, transpire large amounts of water and release volatile organic compounds which can affect the formation of clouds. However, measurement of fluxes is not simple. Eddy covariance (EC) method, although it also suffers from significant shortcomings, has been accepted by the scientific community as the most accurate method for direct flux measurement at the forest stand scale.

In our work we are reporting results of eight years of CO_2 flux measurements with EC at Jastrebarsko pedunculated oak forest (Croatia), which is a part of forest complex of the river Kupa basin. We compared annual productivity (expressed as net primary production; NPP) assessments from EC measurements with field measurements using bi-weekly field observation of tree stem increment of 640 trees in 24 plots set in a 100m x 100m grid. The comparison was made on the bi-weekly and annual basis for the eight years period of measurements, spanning from 2008 to 2015.
Results show good agreement between NPP estimated from EC and the field measurements, although agreement is slightly worse for years with higher precipitation and for very dry years. These results could indicate that tree's carbon reserves probably play significant role in the overall tree growth dynamics. Further research is needed to assess the role of carbon storage in trees.

VISUAL TREE ASSESSMENT OF TREES IN RECREATIONAL AND ENTERTAINMENT CENTER "PIONIRSKA DOLINA" AND SPECIAL EVALUATION OF SOME VTA METHODS

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KEYWORDS:
city trees management, park safety, tree care, tree hazard assessment, visual tree assessment (VTA)

Main goals of this research paper were visual tree assessment (VTA) on four longest visitor time spent areas- research test planes and evaluation of some VTA methods.

Data collection on site was done using Tree Hazard Evaluation Form (THEF) method developed by International Society of Arboriculture (ISA). Assessment results showed that although most of trees have been pruned in the past they still have parts of the tree that can cause damage to their environmet. Seventeen tree species and nine pests have been found. Average tree population stage is in transition from semi-adult to adult while average crown transparency is 24,33%. Almost half of trees 42% are under some sort of pests influence.

All planes contain at least one tree that needs urgent and detailed analysis in order to obtain visitor safety in the area. Average slenderness factor (H/D) was 34,15 while average tree hazard rating was 7,62. Overall state can be described as satisfactory but it is of most importance that proper tree care is carried out so maximal visitor safety can be attained.

While adepted VTA_hr method requires less time and parameter-wise is a little bit more in-depth, THEF is more apropriate for more detailed visual assessment because as it allows more precise assessment and generates hazard rating that is useful for tree management and tree care planning.

FORESTS AND FOREST GENETIC RESOURCES AS A POTENTIAL SOURCE OF ECOSYSTEM SERVICES AND PRODUCTS – NUCLEUS OF A CONCEPT IN THE REPUBLIC OF SERBIA FOREST POLICY AND MANAGAMENT

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KEYWORDS:
climate change, ecosystem products, ecosystem services, forests, national programmes, sustainable development

Ecosystem services and products of forest genetic resources are only one part of the overall context of ecosystem services on the planet. Currently, the greatest challenge is to estimate the actual economic significance of diversity of services and products which forest ecosystems and forest genetic resources provide to people. In many countries, forest ecosystem services and products have been identified and they are systemically and socially recognised. There are numerous initiatives to further define forest ecosystem services and products as well as to profile them and estimate their economic and financial benefit in the context of climate change throughout the world. Evident climate change substantially affects the changeability of forest ecosystems and forest genetic resources on the planet, which further complicates assessment of economic importance of forest ecosystem services and products worldwide. For this reason, their identification, protection and preservation need to be obligatory activities to which special attention should be paid when being valorised and exploited. This study explains the concept of ecosystem services from the aspect of forestry and national strategies of adaptation to climate change, the FAO and certain countries which integrated into their essence the importance of the protection of forests and forest genetic resources and rational use of their ecosystem services and products. Also, taking into the consideration that there are no official data in the Republic of Serbia on the types of ecosystem services and products provided by forest genetic resources and thus there is also no knowledge on their potential and actual economic value, another aim of this study is to propose strategic framework of their identification and research. This will make way to different bio-economic research activities which will shed light in the next decade (2016-2025) on the exact ecosystem services and products provided by the forests and forest genetic resources and their economic value for local self-government units and the entire country through creating national programme and other policy and management tools and mechanisms which integrates sustainable forest ecosystem services and products monitoring, exploitation, conservation and economic valorisation. This study is done under the project supported by the Ministry of Education, Science and Technological Development of Republic of Serbia.

FLOODPLAIN OAK FORESTS IN PROTECTED AREAS OF CROATIA: HOW MUCH, WHEN AND WHY?

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KEYWORDS:
floodplain forests, Natura 2000, nature protection, pedunculated oak

The unique and highly diverse pedunculate oak floodplain forests all but disappeared from European riverine landscapes due to the conversion of forests to agricultural land, construction of hydropower plants, river regulation and flood protection. Unlike many other countries in Europe, Croatia managed to retain a large share of the area once covered with old-growth oak floodplain forests. In many instances, areas of felled old growth forests were regenerated with pedunculated oak resulting in contemporary floodplain oak stands. Current stands differ in structure compared to old growth forests, but have retained significant share of its original biodiversity which led to the high percentage of these forests being protected in some kind of nature protection category. In some cases, the same forest stands are protected under several protection categories resulting in differing jurisdictions and implications for forests management. Aim of our contribution is to analyze the protection status of managed oak floodplain forests in Croatia with regard to the timing of protection and distribution of forest area in national nature protection categories and Pan-European Natura 2000 network. For the purpose of this exercise we used readily available spatially defined sources we analyzed in the GIS environment. Distribution of floodplain oak forests in Croatia was extracted from the map of habitat types according to the National habitats classification of Croatia. Total area analyzed amounted to 110,370.29 ha. Forest area was overlaid with areas of national nature protection categories, polygons of National Ecological Network (2007-2013) and Natura 2000 sites (2013-). Today, 72% (79,470.72 ha) of analyzed floodplain oak forests in Croatia are under some category of nature protection. Under national nature protection categories, floodplain oak forests are protected as significant landscapes (13.87%), nature parks (12.12%), special reserves (1.03%) and regional parks (0.24%). In 2013 the Pan-European Natura 2000 network was established with the accession of Croatia to European Union. Currently 66.04% of floodplain oak forests are included in SPA sites and 54.13% in pSCI sites. In some instances, the same forest stands are protected under two national categories of nature protection (e.g. nature park and special reserve) and two Natura 2000 site types (SPA and pSCI). We discuss in our contribution the underlying responsibilities, protection measures, planning process and other aspects of forest management that are influenced or need to be adapted in the case of managing forests under single and multiple protection categories.

ASSESSING RURAL AND AGRICULTURAL RIPARIAN AREA OF GREECE WITH THE USE OF GIS AND SVAP

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KEYWORDS:
best practices, conservation, new technologies, visual assessment protocols

The designation of many riparian areas worldwide as protected indicates their importance. The reason for their protection resulted by alterations induced by humans along with the many ecosystems services they offer. They are adjacent to rivers and lakes and are considered corridors characterized by higher levels of fauna that tolerant flood conditions. While in most countries their importance has been a high priority, in Greece only in the last decade riparian research has been brought in the forefront. An important aspect of riparian areas is their assessment in order to maintain their healthy functioning and structure. The purpose of this research was to evaluate tools for the quick evaluation of riparian areas to help land managers better conserve and sustain them. More specifically, this study assessed a riparian area along a perennial stream adjacent to rural and agricultural areas located in Drama Prefecture, in the Eastern Macedonia region of Greece. The selected site is typical of riparian areas in lowlands in the Mediterranean. It was decided to use a field method along with a computrer software. Specifially as the field method, the Stream Visual Assessment Protocol (SVAP) protocol was chosen. It is a "rapid assessment protocol", since it provides a quick, visual and systematic assessment of these natural ecosystems. In addition, this protocol allows the collection of data without interfering and altering ecosystems, while it can be applicable to many regions. In regards to the computer software we used the Geographic Information Systems (GIS) to evaluate these areas by integrating, storing, analyzing and presenting geographic correlated data. This evaluation used the buffer funcntion in GIS and found that the riparian areas, even right along the stream bank in some cases, had irrigated and non-irrigated agricultural crop fields, discontinuous urbanized areas but also discontinuous broadleaved. Based on the SVAP protocols, the riparian area was highly degraded due to human interferences. Overall, the combination of SVAP and GIS provide tools to land mangers to evaluate quickly and effectively riparian areas in rural and agricultural landscapes that will help them make management decisions in order to enhance and conserve riparian areas to maintain scosystem services.

APPLICATION OF UNMANNED AERIAL VEHICLE FOR MISTLETOE DETECTION

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KEYWORDS:
mistletoe detection, pedunculate oak, silver fir, unmanned aerial vehicle (UAV)

Unmanned Aerial Vehicles (UAV) have a wide range of applications in the forestry. They are used for wild animal movement tracking and determination of their population density, supervision over forest fires, monitoring of tree damage and related decline, for control and mapping of the infected area under the influence of biotic factors (pests and diseases) in inventorying and management of forest resources, and for many other purposes.

In the future we can expect increased use of UAV in forestry, especially when we need fast and reliable data acquisition for small or inaccessible areas. This is related with the inability of the current remote sensing methods to record small areas (aerial and/or satellite images).

The largest contribution to the recording UAV is a high spatial resolution in a smaller area, which is possible, if the need arises, be limited to an individual tree. In this research special attention was given to mistletoe detection in a tree crown using UAV.
The results of the terrestrial validation of mistletoe presence in a tree crown showed that this detection method is not reliable. Inability to detect mistletoe does not mean that analyzed trees are not infected, because mistletoe bushes can be covered by tree branches. In addition, mistletoe can occasionally get overlooked due to an inability of detailed review of each branch off the ground. Therefore, in order to avoid terrestrial method limitations, arial recording of misletoe on the silver fir and pedunculate oak was conducted using UAV (hexacopter).

The results showed that the use of UAV enables an efficient and reliable method for mistletoe detection, and allows mapping and percentage share calculation of the mistletoe infestations. Data collected using UAV provide useful base and guidelines in the field of forest management, silviculture, protection, ecology and forest exploitation.

STANDARD INCREMENT SERIES FOR COMMON BEACH (*Fagus sylvatica* L.) IN EVENAGED FORESTS OF NW CROATIA

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KEYWORDS:
common beech, evenaged forests, forest management plans, increment, standard increment series

Information about increment on tree species level for every subcompartment is a part of forest management plans. According to forest management rules act (NN 79/15), a method of getting data on volume increment is based on current radial increment. In order to produce volume increment percentages for every diameter class, samples are separated into groups by forest type, site quality and age.

After analysis of local increment series that are in use in NW Croatia, and which showed some disadvantages, simple equalization of existing series is made. Evenaged forests with common beech (Fagus sylvatica L.) as a main tree species in NW Croatia managed by Regional Forest Office Koprivnica, are divided in 2 ecological-geographical regions: Bilogora and Prigorje region with area of 19000 ha and Kalnik with area of 14800 ha. Currently used local increment series are grouped according to: region – forest type – site quality – age, and mean values for each diameter class is calculated. New, standard increment series for common beech can be helpful in reducing field work costs during forest management process.

Keywords: common beech, evenaged forests, forest management plans, increment, standard increment series

GOOD PRACTICE EXAMPLES IN VOCATIONAL EDUCATION AND TRAINING AND LIFELONG LEARNING IN SUSTAINABLE FOREST MANAGEMENT IN AUSTRIA, CROATIA AND SLOVENIA

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KEYWORDS:
adult education, educational programmes, forestry knowledge transfer

In 2013, the European Union (EU) established the Union programme for education, training, youth and sport, Erasmus+. During the Erasmus+ project "Cooperation for Innovative Approach in Sustainable Forest Management Training (CIA2SFM)" a study of existing vocational education and training (VET) and lifelong learning (LLL) programmes in the field of sustainable forest management (SFM) was conducted in the study area - Austria, Croatia and Slovenia.

The aim of the paper is to get an overview of VET and LLL programmes in the study area, with an emphasis on the identification of good practice examples in the field of SFM. A combined approach of literature studies and a survey amongst national experts was applied.

Survey results indicate that there is a broad interest in the study area to foster education in the forest-based sector within national VET and LLL programmes. Numerous SFM related training courses are offered in each of the countries, predominantly addressing an array of forestry stakeholder groups. There is broad portfolio of topics that are spread across national classrooms although the relative importance of focal points differs notably between countries. Various methods are applied in order to facilitate the uptake of knowledge by trainees (or learners) however, indoor ex-cathedra approaches are the dominant means to transfer state-of-the-art knowledge on forestry related issues. Nevertheless it could be recognized that there is an increasing interest to facilitate the practical understanding by fostering demonstrations in the field, organizing field trips or emphasize practical work in most countries.

Even if focal points may relate to individual needs within national forestry sectors, SFM related VET and LLL programmes should be regularly screened and updated according to international agendas and emerging issues. In order to cope with increasing uncertainty and expanding risks forest ecosystems are facing, it is an important task to provide forestry stakeholders with the know-how to address the diverse challenges they are facing when managing their forests sustainably.

CLIMATE SMART AGRICULTURE AND FORESTRY AS PART OF SOLUTIONS TO FIGHT GLOBAL CLIMATE CHANGE - INCLUSION OF LAND USE IN EU'S POST-COP21 POLICY FRAMEWORK

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KEYWORDS:
CAP, COP 21, CSA, INDC, LULUCF

Anthropogenic climate change is one of major environmental threats we are facing today. Although the development of international climate initiatives and evolution of climate policies significantly evolved since the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, in efforts to fight global climate change the key role is taken by the European Union (EU) and its member states, as proved by the last COP 21 in Paris.

The Paris Agreement adopted in December 2015 by all UNFCCC parties is the first-ever universal legally binding global climate agreement foreseen to minimalize the devastating effects of the occurring present and most likely future climate events, and to keep the global warming below 2°C. However, the voluntarily proposed Intended nationally determined contributions (INDC) may not be sufficient to achieve aims of the Agreement. On the other hand, agriculture and land use change, along with forest degradation and loss, are responsible for 25% of Greenhouse Gas (GHG) emissions. By 2050 the sector could be responsible for more than half of the global GHG emissions.

With advancement in implementation of the Paris Agreement, the agricultural production that is environmentally sustainable and climate efficient, together with forestry, more than ever came into focus as part of solutions to fight global climate change. By promoting Climate–Smart Agriculture (CSA) and carbon sequestration, and by integrating them into Common Agricultural Policy (CAP) and the EU's Post-COP 21 policy framework; same as by including the Land Use, Land Use Change and Forestry (LULUCF) into the 2030 greenhouse gas mitigation framework, the EU policy would not only align itself with the UNFCCC provisions, yet would also significantly contribute to the sustainable food security under the climate change.

APPLYING THE NOTG MODEL TO FOREST SITES IN CROATIA

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KEYWORDS:
Aleppo pine, meteo data, NOTG model, soil

NOTG is the process- and individual-based model which was designed to predict growth and carbon and water fluxes from the tree to the ecosystem, explicitly accounting for ecosystem spatial structure and multispecific canopies. It already incorporates the main biophysical processes involved in the water, carbon, and nitrogen cycles in trees and soil. NOTG was also primarily applied to mediterranean forests, including the effects of drought on plant physiology and soil organic matter decomposition. As a first case study, the model was parameterized for the forest of Font-Blanche, a mixture of Aleppo pine and Holm oak in south-east France. Therefore, the purpose of model application to Croatian Aleppo pine site was: to fill-in knowladge gaps by using process-based modeling at varius spatial and temporal scale, to extend the use of the model in new places, to confirm if they are applicable to experimantal sites. Aleppo pine was planted on three separated blocks (3 repetitions), distributed over the experimental object according to randomized block method. Each block has an area of 0.2 hectares and it is divided longitudinally into 2 sub blocks. Each year during the experiment from 2003 to 2014, after the growing season, seedlings were measured for height increment, and survival rates, with respect to container type and planting method. The objectives was to study climate change impacts on Aleppo pine sustainability and productivity across time. Measurements used: biomass and leanght of 1 year old seadlings, mortality and growth of plants planted in pits and ripped soil, soil profile analyses and meteo data obtained from Croatian Meterological and Hydrological service. We will provide an extensive evaluation of the model for a well documented Aleppo pine site, using measurements at the tree, soil, and ecosystem levels. Our results will bring new insight into the use of ecological model to assess local changes in ecosystem functions in response to climate change.

Session B:

FOOD AS NATURAL SOURCES OF FUNCTIONAL INGREDIENTS

NUTRITIONAL QUALITY AS PART OF SUSTAINABLE FOOD PRODUCTION

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KEYWORDS:
food safety, nutritive quality, quality, sustainable production

Food, as one of the fundamental human needs, plays one of the most important roles in health preservation. Unbalanced diet will result in malnutrition and diseases due to deficiency of essential nutrients, or obesity and health problems associated with obesity and excessive intake of nutrients. According to WHO data, the incidence of metabolic diseases associated with dietary habits, such as cardiovascular disease, diabetes, osteoarthritis and some cancers (endometrial, breast, colon) is continuously increasing (WHO, 2015)[1].

Food industry certainly plays one of the most significant roles in the modern world and influences the dietary habits of a broad population of consumers. In many areas, the industry is setting standards, participating in the promulgation and enforcement of regulations and laws, and affecting customer choices and behaviours through its offer of products and provision of information. As regional leader in the manufacture, distribution and sale of food, we are aware of our impact on the community, as well as obligation to help a broad population of our customers and consumers to acquire better dietary habits.

Our approach is based on continuous improvement of the nutritional quality of our product range in several directions; by reducing the content and improving the quality of fat, reducing the amount of sugar, reducing the amount of salt, enriching products with micronutrients (e.g. vitamins and minerals), using natural ingredients, customizing products for consumers with special dietary needs, as well as by consumer education. We consider the assurance of quality of our products, processes and services an imperative. Systematic assurance of food safety is based on HACCP (Hazard Analysis and Critical Control Point) principles applied to identify, assess and control potential risks for prevention purposes. We promote high quality standards as well as share them with our suppliers, partners and customers, for sustainable product and service quality levels.

[1] WHO,2015, http://www.who.int/mediacentre/factsheets/fs311/en/

AIM AND IMPORTANCE OF TAXONOMY, ECOLOGY AND UTILIZATION OF CAROB TREE (*Ceratonia siliqua* L.) AND BAY LAUREL (*Laurus nobilis* L.) FOR SUSTAINABLE DEVELOPMENT OF CROATIAN COAST AND ISLANDS

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KEYWORDS:
bay laurel, carob, ecology, food supplements, sustainable development

Carob tree (*Ceratonia siliqua* L.) is nutritionally and protectively very valuable plant, especially seeds which are widely used in the food industry. Carob pods and juice has a very important role in diet of Mediterranean countries. Bay laurel (*Laurus nobilis* L.) is also nutritionally and protectively very valuable plant overspread on the Mediterranean basin. The most important parts of the bay laurel plant are leaves which are used in traditional medicine, and in the food, pharmaceutical and cosmetic industries. Both species are also an important component of the Mediterranean vegetation and grows in marginal and prevailing calcareous soils. Knowledge about Croatian populations of carob tree and bay laurel is quite limited and these studies will be conducted to determine morphological, genetic, phytochemical and ecological traits of Croatian populations of these species. Additionally, possible positive effects of addition supplement of carob tree in standard food for animals on health and production parameters in weaned pigs as the natural replacement of antibiotic growth promoters will be investigated. Respecting the small level of pollution of Croatian islands and some coastal areas, growing, and processing of bay laurel is completely complementary with growing of carob trees might have a positive impact green and sustainable development. In this presentation the results achieved during the first research year of research project TEUCLIC will be exposed. The project is financed by the Croatian Science Foundation under the grant number HRZZ IP-11-2013-3304 TEUCLIC.

WASTE BIOMASS OF MUSHROOM *Agaricus bisporus* AS A SOURCE OF ANTIOXIDANTS

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KEYWORDS:
Agaricus bisporus, antioxidant activity, flavonoids, total phenols, waste biomass

Agaricus bisporus, known as white button mushroom or champignon, is the most cultivated mushroom. Its good nutritional characteristics due to the low fat, high protein and carbohydrate content, among which dietary fibers are predominant, make this mushroom almost ideal dietary foodstuff. In addition, it contains a great deal of antioxidative substances as well as polysaccharides, such as *β*-glucan, which has been reported for its immunomodulatory activity. Waste champignon biomass, containing mainly lower parts of champignon stalks, is a secondary product which is gained during the harvesting stage. Although this material is edible, there is not a suitable market for its distribution in Croatia. In order to explore the possibilities of using the waste biomass, its antioxidative potential was analysed using three different methods. Compared to fresh table A. bisporus intended for Croatian market, a lower antioxidant properties may be noticed in the waste biomass. It was probably caused by degradative changes which have occurred during the storage, or by an uneven distribution of the antioxidative compounds between the various parts of the mushrooms since the waste material mainly consisted of stalks and not of whole fruiting bodies. Portions of total phenols and flavonoids important for antioxidative properties were also analysed. FT-IR analysis was used to characterise the presence of compounds that cause antioxidative activity. The obtained results showed that the waste biomass of *A. bisporus* could be used as a source of antioxidants.

APPLICATION OF INNOVATIVE TECHNOLOGIES FOR PRODUCTION OF PLANT EXTRACTS AS INGREDIENTS FOR FUNCTIONAL FOODS

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KEYWORDS:
anthocyanins, chokeberry, cold atmospheric gas phase plasma extraction, microwave extraction of Dalmatian sage, pomegranate

Various parameters of three different innovative technologies were studied and associated with different polyphenolic profiles in plants:

1) microwave extraction of Dalmatian sage (*Salvia officinalis* L.) extracts that aimed to evaluate the influence of solvents (30% ethanol/water, v/v; 30% acetone/water, v/v; water), time (3,5,7,9,10 min), temperature (30, 50, 60, 80 °C), and acidity (addition of 10 % HCl) on polyphenolic recovery. Total polyphenols were best extracted with 30% acetone/without HCl/T=80°C for 10 minutes. The main polyphenol, rosmarinic acid was best extracted with 30% ethanol/with HCl at T=80°C for 10 minutes;

2) cold atmospheric gas phase plasma extraction of anthocyanins from pomegranate (Punica granatum L.) juice. Plasma treatment covered different operating settings: (i) time (3, 5, 7 min), (ii) juice volume (3, 4, 5 cm^3), and (iii) plasma gas flow (0.75, 1, 1.25 dm^3/min). Anthocyanins were best stable at: 3 min of treatment time, 5 cm^3 sample volume, and 0.75dm^3/min gas flow. Anthocyanin content was higher for 21-35% in plasma treated samples vs. fresh juices. In summary, it was shown that plasma treatment had positive influences on anthocyanins stability in cloudy pomegranate juice;

3) cold atmospheric gas phase plasma of chokeberry juice (Aronia melancarpa) extracts that aimed to evaluate influence of different treatment times and juice volumes under constant gas flow (0.75 dm^3min^{-1}) on polyphenolic content. All samples were compared to the fresh and pasteurized chokeberry juice (80°C/2min). Plasma treatment better preserved hydroxycinnamic acids, but showed loss of anthocyanins. Pasteurisation negatively affected hydroxycinnamic acids, while flavonols and anthocyanins were well preserved.

KINETICS AND THERMODYNAMICS OF THE SOLID-LIQUID EXTRACTION PROCESS OF TOTAL POLYPHENOLS, ANTIOXIDANTS AND EXTRACTION YIELD FROM NETTLE (*Urtica dioica* L.)

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KEYWORDS:
antioxidant capacity, extraction yield, kinetic modelling, solid-liquid extraction, total polyphenols

Solid-liquid extraction process is a simple method used in many food industries. This method is widely used for effective separation of bioactive compounds from plant material. The goal of every extraction process is rapid and effective isolation of desired compounds from a plant matrix with high yield. In order to obtain the highest possible amount of bioactive compounds from plant material using solid-liquid extraction, detailed analysis of the extraction process dynamics is of upmost importance. According to literature data, solid-liquid extraction process usually follows a kinetic curve illustrating that the rate of mass transfer is not constant. The extraction curves usually consist of two phases; constant extraction rate period and diffusion controlled period. To reduce the number of experiments and to get a good insight into the extraction process, mathematical modelling is often used. Mathematical modelling of solid–liquid extraction processes is an important engineering tool in process design in order to reduce energy, time and chemical reagents consumption. The possibility to extract the highest possible amount of valuable compounds in a short time is of significant interest for practice.
In this work, solid-liquid extraction process of total polyphenols, antioxidants and extraction yield from nettle in batch reactor with continuous stirring and controlled temperature were analysed. The applicability of three kinetic models (Peleg's, Page's and Logarithmic model) for description of solid-liquid extraction was tested. To get detailed insight into the extraction process, initial extraction rate, extraction capacity, activation energy, Gibbs energy, enthalpy and entropy were determined.

ELEMENTAL ANALYSIS IN A VARIETY OF AGRICULTURAL AND FORESTRY CONTEXTS

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KEYWORDS:
biomass, elemental analysis, fertilizer, protein analysis, soil

There are many aspects of the agricultural and forestry industries that rely on knowing the nutritional or caloric properties of related soils, plants, or wastes. Elementar offers a wide variety of instruments well suited to these purposes. Instruments range from analyzers for simultaneous determination of several elements to those dedicated to the rapid measurement of a single element. Not only can small, homogeneous samples be measured, but soil samples up to 5 g can also be measured, reducing the amount of sample preparation necessary. Applications include measuring the nitrogen content of fertilizer, the CHNS content of soil, the CHNS content of bio-oil and biomass, and the CHNS content of plant materials. The precision of these measurements routinely falls below $\pm$0.05% absolute concentration. The detection limit of these measurements is in the ppm range and is well-suited to a variety of purposes, as illustrated by the ability to determine the protein content of starch. The large absolute capacity of the trapping mechanism allows for large samples, up to 500 mg absolute carbon content. Operating according to the Dumas principle of high-temperature combustion followed by reduction, these instruments are themselves examples of green chemistry, producing no toxic wastes. They are also highly sustainable with options to operate with carbon dioxide or argon as carrier gases, as opposed to the commonly-used helium, which is a limited resource.

HEALTH PROMOTING AND SENSORY PROPERTIES OF CROATIAN MONOVARIETAL VIRGIN OLIVE OILS

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KEYWORDS:
health, monovarietal, sensorial evaluation, virgin olive oil

As a typical component of the Mediterranean diet, virgin olive oil is consumed unrefined and it is rich in important molecules, such as minor polar compounds (hydroxytyrosol, tyrosol, secoiridoids and flavonoids) and fatty acids. These molecules not only influence the sensorial properties of both olives and virgin olive oil but they are also important markers for typicity, biodiversity and quality determination of this product. The aim of this study was to evaluate the minor polar compound and fatty acid contents of monocultivar virgin olive oils, typical in Dalmatia olive region, in order to have better knowledge about the quali-quantitative profiles of these compounds in samples obtained from both the same collecting season and same processing technique. Quali-quantitative analysis (performed by HPLC/DAD and GC) could be a useful tool to better correlate the typicity of the virgin olive oil with its minor polar compound and fatty acid pattern. The results showed that within the germplasm studied a great variation was present both in fatty acid and phenols composition related to genetic origin. The sensorial assessment was also performed on the investigated olive oil samples in order to define their sensorial profiles regarding cultivar. Further studies are in progress to isolate the specific aroma compounds in order to investigate their impact to biological, nutritive and sensorial properties of these oils.

CONCENTRATIONS OF MERCURY DURING HONEYBEE WAX PROCESSION

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KEYWORDS:
beeswax, comb foundations, mercury concentrations

Beeswax foundations are necessary material in intensive modern beekeeping. In hives it plays an important role for honeybee colony as a part of construction material for comb cells where brood is situated, and where nectar and honey are stored. Honeybee wax can be a useful tool for collecting information about environmental contamination with toxic metals. Hg is the main toxic metal in environmental pollution that can contaminate apian products, primarily combs. Presence of Hg "in hive" contamination may cause a wide range of toxic effects, including organic, neurological or behavioural disorders. Also, it is a common beekeeping practice to continuously recycle wax, more precisely old combs. Because Hg cannot be destroyed or degraded, presence and its accumulation in honeybee wax, through the food chain can lead to ecological issues with dire consequences. The aim of this study was to determine and compare concentrations of Hg from material sampled from different layers of melted wax during the processing using casting technology with prolonged term of cooling, and comb foundations as final product. The concentrations of Hg in 24 beeswax samples were measured without acid digestion using the AMA-254 (Advanced Mercury Analyzer, Leco, Poland), which employs direct combustion of the sample in an oxygen-rich atmosphere. Measured values of Hg concentrations in different layers were in the range (μg/kg): 1,0 – 95,3 one day after resolving wax combs (and then the precipitate is removed), 2,67 – 14,5 after sterilisation and prolonged cooling with precipitation of seven days at 75 ^{0}C. Obtained results can be an indication and recommendation to wax comb foundation producers to use described technology.

ELECTROCHEMICAL DETERMINATION OF TOTAL POLYPHENOLS CONTENT IN APPLE PEEL EXTRACTS

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KEYWORDS:
apple peel extracts, differential pulse voltammetry, quercetin, total polyphenols content determination

The aim of this study was to examine electrochemical properties of quercetin (a flavonoid widely distributed in fruits and vegetables, e.g. apples, broccoli, red onions, plums etc.) in different electrolytes and to use quercetin as a standard for electrochemical detection of total polyphenols content in apple peel extracts. Electrochemical properties of quercetin were studied in three different electrolytes (KCl, NaCl, LiCl) by differential pulse voltammetry (Ic = 0.34 mol dm^{-3}). Measurements were conducted in a three electrode voltammetric cell in an aqueous media. Glassy carbon was used as a working electrode, platinum wire as counter electrode and Ag/AgCl electrode as a reference electrode. Inert atmosphere was acomplished by system purging with high purity argon Ar 5 (φAr = 99.999 %), before each measurement. Differential pulse voltammograms of quercetin revealed three oxidation peaks in all three electrolytes, which were associated with oxidation of five -OH groups of quercetin. The first oxidation peak of quercetin was chosen for quantification of total polyphenols content since linear dependence of I_p vs. quercetin concentration was found in all three electrolytes. The best calibration diagram (R^2= 0.9924) was obtained in 0.34 mol dm^{-3} KCl solution in quercetin concentration range from $1.0 \cdot 10^{-6}$ mol dm^{-3} to $1.6 \cdot 10^{-5}$ mol dm^{-3}. So this diagram was used for quantification of total polyphenols in apple peel extracts.

MINERAL COMPOSITION AND HEAVY METALS CONTENT OF SWEET CHESTNUT FRUITS IN FIVE NATURAL POPULATIONS FROM CENTRAL CROATIA

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KEYWORDS:
fruits, heavy metals, mineral composition, natural populations, sweet chestnut

In recent years the consumers have been showing an increased interest in chestnut fruits because of their nutritional qualities and potential beneficial health effects. Since the information about nutritional composition of the fruits from the natural populations is still limited the aim of this study was to analyze their mineral content.
Nuts were sampled in five natural populations, from the central area of sweet chestnut distribution range in Croatia. Each population was represented with five trees. Macro and micro elements (K, Ca, Mg, Na, Fe, Zn) and heavy metals (Pb, Cd, Hg, As) were determined by atomic absorption spectrophotometry using a Varian SpectrAA 220 device. Univariate and multivariate statistical techniques were used to evaluate the differences among populations.
Chestnuts of all five populations contained K, Ca, Mg, Na, Fe, Zn in average (mg/100g) 613.96, 35.17, 29.99, 3.69, 1.37 and 0.70 respectively. The obtained results for heavy metals content provided evidence that the concentrations were lower than the toxic law limits. An analysis of variance showed significant difference between populations regarding each mineral. The study also confirmed a trend of population variations according to the eco-geographic principle.

ANTIFUNGAL ACTIVITY OF THE GARLIC *(Allium sativum L.)* ESSENTIAL OIL AGAINST ASPERGILLUS SPECIES ISOLATED FROM FOOD

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KEYWORDS:
antifungal activity, Aspergillus spp., food, garlic

Although rapid technological advances during the last decade have caused the introduction of new technologies in food production in order to obtain sanitarily, nutritiously and technologically safe products, the occurrence of fungi and their secondary toxic metabolites - mycotoxins in food products is not neglectable. On the other hand, today's consumers have high demands for procurement of food that is minimally technologically processed and without synthetic preservatives or additives, because of the possible adverse health effects.

The use of natural antimicrobial agents is considered as good alternative and may be more acceptable to consumers than synthetic food additives because of its natural origin and potential antimicrobial activity, and preservative, antioxidant, and flavouring.

Therefore, the aim of this study was to investigate the antifungal potential of garlic (*Allium sativum L.* cultivar Bosut) essential oil (EO) against *Aspergillus niger*, *A. carbonarius, A. wentii,* and *A. versicolor* isolated from fresh ready-for-use salads and cakes. The garlic EO obtained by hydrodistillation were analyzed by GC/MS. Compounds such as diallyl-trisulfide (33.55%), and diallyl-disulfide (28.05%) were identified as the major components of garlic EO. The effect of garlic EO on the growth of *Aspergillus* species was performed according to the agar plate method.

Applied concentrations of EO (3.5, 7.0, 14.0, and 28.0 µL/100 mL) caused the delay or absence of fungal growth with different inhibitory effects on the deceleration in the growth rate. Garlic EO at a concentration of 28.0 µL/100 mL demonstrated a fungicidal effect (MFC) on the growth of *A. carbonarius, A. wentii, A. versicolor*, and an inhibitory effect on *A. niger.* Macroscopic and microscopic investigations showed that the application of garlic EO caused changes in macro-morphology and micro-morphology of the investigated fungi. The obtained results show that the investigated garlic EO can be used as an antifungal agent in food protection from mycological contamination.

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INFLUENCE OF HEAT TREATMENT ON ANTIOXIDANT ACTIVITY AND POLYPHENOLIC COMPOUNDS OF CULTIVATED MUSHROOMS

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KEYWORDS:
antioxidant activity, flavonoids, heat treatment, mushrooms, polyphenols

Introduction: Mushrooms have been used for traditional foods and medicine because they are high in proteins, dietary fibers, minerals and vitamins but low in calories and fats. The edible mushrooms also contain many polyhenolic compounds, which are able to scavenge free radicals and have been found to be excellent antioxidant material.
Aim: Heat treatment is unavoidable process in preparing mushrooms for a meal. Its influence can be varied on different nutrients. The aim of this study was to evaluate the effect of thermal processing on the antioxidant activity and polyphenolic compounds of cultivated mushrooms grown in Serbia (Agaricus bisporus var. Albidus - white mushrooms, Agaricus bisporus var. Bisporus - brown mushrooms, Pleurotus ostreatus - oyster mushrooms, Lentinus edodes - shiitake).
Method: Determination of antiradical effects on ABTS radical and ferric reducing ability (FRAP), as well as the content of total phenolics in water extracts were performed using standard spectrophotometric assays. Fresh, baked and blanched mushroom samples were analyzed. The results were expressed on the dry matter basis.
Results: Total phenolic (TP) content was the highest in fresh samples of brown mushrooms and it amounted to 4.7 mg GAE/g d.w. In this mushroom 25% decrease of TP was noticed after thermal processing (baking or blanching). On the contrary, baking process has caused an increase in the TP content in shiitake and oyster mushrooms (43% and 118%), while the blanching process has caused two fold higher increase in comparison with baking. In white mushrooms, no significant change was found due to heat treatment in regard to TP content. As far as the antioxidant activity of analyzed samples, ABTS and FRAP assays provided consistent results. So, baking and blanching have decreased antioxidant activity of white and brown mushrooms but increased in shiitake and oyster mushrooms.
Conclusion: Thermal process of fresh mushroom material had varied effects on polyphenol content and antioxidant activity and no general conclusion could be made. Depending on process type and mushroom species increase or decrease of these parameters could be expected and should be investigated on case by case basis. These variations may be explained by specific characteristics, such as shape, colour and texture, of the mushrooms in each species. Increased antioxidant activity after heat treatment could be the result of prevented enzymatic oxidation causing loss of the antioxidant compounds in the fresh mushroom materials.

THE USE OF DIFFERENT EXTRACTION METHODS OF BIOACTIVE COMPONENTS IN LINDEN FLOWER

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KEYWORDS:
bioactive components, extraction, IR-spectroscopy, linden, total phenols

Linden (*Tilia cordata*) is abundantly used in traditional medicine worldwide due to its extensive range of positive effects on human health. Active compounds in the linden flowers include flavonoids (primarily rutin and isoquercitrin), mucilage components, tannins, procyanidins, phenolic acids and essential oils. The type, content, and proportion of these substances may vary depending on environmental factors in areas where the plants are grown. Although the usage of linden is widespread, scientific studies involving evaluation of therapeutic utilization is limited. A part of our research includes isolation of easily volatile bioactive compounds of linden flower using two methods - classical extraction (refluxing) and Soxhlet extraction. The obtained extracts is purified applying preparative thin layer chromatography/ column chromatography and follows characterization of bioactive compounds using IR - spectroscopy. Results of investigation indicate the different content of bioactive components, depending on the solvent used for extraction. Increased content of phenolic compounds was obtained while using binary polar solvents at high temperatures and classical extraction gave a higher amount of phenolic acids compared to Soxhlet extraction. Mass concentration of total phenol compounds in extract obtained employing classical extraction is 125.9 mg GAE/100 g of linden likewise 38.82 mg GAE /100 g of linden using Soxhlet extraction.

POSTDISTILLATION WASTE AS A POTENTIAL SOURCE OF BIOACTIVE COMPOUNDS

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KEYWORDS:
antioxidant activity, Helichrysum italicum, postdistillation waste

Aromatic, condimentary and medicinal plants are the major sources of essential oils. However, essential oil is present in low amounts (0,9-2,5%). Thus, the majority of plant material remains unused after the isolation. The objective of this work was to evaluate waste material extracts obtained from *Helichrysum italicum* plant material remaining after distillation as a potential high added value ingredients. Helichrysum italicum is known for its anti-inflammatory, anti-allergic and antimicrobial properties. The medicinal properties of this plant are mainly attributed to the presence of flavanoids, but they may be also influenced by other compounds such as phenolic acids and antioxidant micronutrients, e.g. Cu, Mn, Zn. The aim of this work was to examine the total phenolic content estimated by the Folin–Ciocalteau reagent method and flavonoid content as well as in vitro antioxidant activity (DPPH free radical-scavenging assay, ABTS assay) of Helichrysum italicum postdistillation waste. Different particle size fractions of postdistillation waste have been studied. Postdistillation waste was vacuum dried, milled and sieved to obtain samples of different average particles (<0,355mm; 0,355-0.63mm; 0.63-1,12 mm; > 1,12 mm). The yield of phenol recovery from plant materials was influenced by variations in the sample particles size since mass transfer can be improved by the use of smaller particles to improve the penetration of solvent in the solid matrix. The obtained results showed that smallest particles (<0,355mm) provided the best recovery of gallic acid equivalents per gram of sample (mg of GAE/100 g of sample). The results of this study will contribute to the recent increase in research on using natural ingredients in many areas of food industry such as nutraceuticals, food supplements and pharmacy (herbal medicinal products and natural products for health care). Further studies should be carried out for isolation and identification of individual phenolic compounds and evaluation of the in vivo potential of these extracts in animal models.

Session C:

GREEN TECHNOLOGY FOR SUSTAINABLE PRODUCTION

GREEN SOLVENTS IN FUEL PROCESSING

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KEYWORDS:
biodiesel, deep eutectic solvents, extraction, fossil fuels, ionic liquids

Ionic liquids and deep eutectic solvents have been considered as green, eco-friendly solvents that could replace commonly used volatile organic solvents. In the fuel processing industries the most important impurities that need to be removed from liquid fuels are sulfur, nitrogen and partially aromatic compounds. Commercial processes for desulfurization and denitrification require high temperatures and pressures, as well as large amounts of hydrogen, making the purification step an expensive and relatively environmentally unfriendly process. As investigated by a number of researchers, green solvents have found their place as selective solvents in an alternative process for removing sulfur, nitrogen and aromatic compounds, liquid-liquid extraction. Both types of solvents posses similar properties, such as high solutes capacities, low vapor pressure, stability, simple regeneration, reusability and tunability, but deep eutectic solvents are much cheaper and greener. Based on the published articles, ionic liquids show higher extraction efficiencies than deep eutectic solvents, but generally speaking, deep eutectic solvents can be used to remove a wider range of the key components' concentration. Recently, the possibility of using both ionic liquids and deep eutectic solvents in the production of biodiesel is being investigated. These solvents can be used as reaction mediums, cosolvents or catalysts for the sinthesys of biodiesel and as selective solvents for the purification of raw vegetable oil or animal fat as well as for extraction of impurities from raw biodiesel. Short review of the application of green solvents in the processes of separation of impurities from fossil fuels and biodiesel will be presented.

EVALUATION OF ANTIOXIDANT ACTIVITY OF ARONIA *(Aronia melanocarpa)* SUBCRITICAL WATER EXTRACTS USING ELECTROCHEMICAL DNA BASED BIOSENSOR AND SPECTROPHOTOMETRIC METHODS

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KEYWORDS:
antioxidants, DNA based biosensor, natural plant products, subcritical water

Aronia (*Aronia melanocarpa*) represent one of the richest known sources of dietary polyphenols and anthocyanins which suggest its extremely high antioxidant activity. Furthermore, scientific evidence showed that both aronia and its extracts may be utilized as an aid in the prevention of diabetes and diabetes-associated complications, cardiovascular diseases, antimutagenic, anticancer and lipid-lowering effects. In the frame of this research, chemical composition and antioxidant activity of subcritical water extracts of aronia were evaluated. Phenolic compounds from different plant parts (fruit, leaf and stems) were selectively extracted by subcritical water in house-made extractor within 30 min. Operational parameters included the pressure of 40 bar, temperature of 135ºC and convective mass transfer defined by vibration frequency of the reaction vessels of 3 Hz. The sample ration was 1:20. Obtained extracts were assessed in terms of their polyphenolic compounds and antioxidant capacity properties by performing a "battery" of assays. Contents of bioactive compounds (total phenolic and flavonoid contents) were measured using spectrophotometric procedures and the total antioxidant capacity was determined by spectrophotometric methods (DPPH and FRAP assay) and DNA-based biosensor against the reactive oxygen species: HO In general, leaf extracts showed highest phenolic and flavonoid contents (131.53 mg CAE/g and 88.64 mg RE/g, respectively) which was in correlation with its highest antioxidant capacity evaluated by FRAP and DPPH assays (87.99 mg AAE/g and 98.83 mg TroloxE/g, respectively). DNA-based biosensors which intends to simulate an in vivo assay by exposing DNA layer to biological ROS and antioxidants showed that all three observed extracts possess strong antiradical activity against HO.

APPLICATION OF NANOSUSPENSION IN EXTRACTIVE DENITRIFICATION AND DESULFURIZATION OF FUELS

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KEYWORDS:
deep eutectic solvent, denitrification, desulfurization, extraction, nanosuspension

In order to protect environment and meet the very strict requirements which are imposed in recent years, denitrification and desulfurization are the subject of great interest. The conventional method of removing sulfur and nitrogen compounds (hydrodesulfurization) requires high temperatures and pressures as well as large amounts of hydrogen and it is necessary to find new and environmentally friendly methods of fuel purification.

Well designed liquid-liquid extraction can be one of such processes. Extraction is considered environmentally friendly process since it operates under mild conditions (low temperatures and pressures) and a possible choice of favorable solvents. Comparable yields of removing undesirable components in extraction process is tried to be achieved by application of so called "green solvents" (ionic liquids and recently deep eutectic solvents, DES). Despite of the green character of DES, low efficiency of desulphurization and denitrification can be the problem for widespread use. Although, the application of DES has been subject of the many researches in the last few years, this paper made a step forward by applications of DES in nanotechnology. Namely, a significant improvement in the mass transfer is achieved by using nanosuspension in the extraction process. For synthesis of DES choline chloride (CHCl) was selected as a typical hydrogen bond acceptor and glycerol (Gly), glucose (Glu) and malic acid (MA) as a hydrogen bond donor. Nanosuspensions were prepared by dispersing nanoparticles of Al_2O_3 (0.3% vol.) in these DESs. Applied nanosuspension was stable over 15 days. Physical properties (density, viscosity, and pH) of DESs and prepared nanosuspensions were determined. Extraction of phiridine and tiophen have been performed with DES and corresponding nanosuspensions (CHCl:Gly, CHCl:MA with 30 wt % H_2O and CHCl:Glu30 with 30 wt % H_2O). For all performed experiments and all used solvents, extraction efficiency of pyridine was higher than the efficiency of thiophene. Extraction of the key components from isooctane as the primary solvent gave the best results.

It was confirmed that the applied nanoparticles mostly enhance mass transfer for all tested systems, in some cases up to 40 %. This improvement can be explained with Brownian motion of well-dispersed nanoparticles which enhance mass transfer.

ECOTOXICOLOGY IN THE SERVICE OF GREEN TECHNOLOGY

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KEYWORDS:
deep eutectic solvents, ecotoxicology, green technology, in vitro cell cultures, ionic liquids

The green technology is defined as design of chemical products and processes that reduce or completely remove the synthesis and application of harmful and hazardous substances. Volatile organic solvents account for almost 2/3 of all industrial emissions causing many adverse effects on the environment. According to the green chemistry principles, selection of a suitable replacement for organic solvents is based on on a reasonable compromise between economic, social and environmental requirements. Therefore, synthesis of alternative solvents must be environmentally friendly i.e. synthetic methods should be designed in such a way that the substances toxic to humans and the environment are not used and nor produced. Also, it is important that after their application, they break down into harmless degradation products which do not accumulate in the environment. Ionic liquids (ILs) and deep eutectic solvents (DESs) attracted the most attention as a possible alternative solvents, due to their low volatility, non-flammability, high thermal, chemical and electrochemical stability and in particular the possibility of recycling. They are unlikely to act as air contaminants or inhalation toxins, but they can be potential water and soil contaminants resulting from accidental spills or lack of wastewater treatment effectiveness. Therefore, their persistence in the water and soil, (bio) degradation and bioaccumulation in aquatic or terrestrial organisms play important role in their overall environmental impact and fate. All those aspects are investigated in the field of ecotoxicology.

The number of newly synthesized alternative solvents increases yearly and therefore simple and reliable methods for their ecotoxicological assessment are necessary. Toxicity assessment of alternative solvents is carried out by a series of tests on various living organisms (in vivo) or animal cells cultures (in vitro) in order to collect data on their impact on humans and environment. So far toxicity of ILs and DESs was determined toward bacteria, yeast, algae, multicellular organisms such as nematode, water snail, water flea, zebra fish, duckweed, cressspring barley and in various cell lines. Obtained results gave valuble answers about the relationship between solvent structure and their toxicity, as well as possible mechanisam of action. Creating a database of environmentally benign structure moieties of ILs and DESs, based on their toxicological and biodegradation data, has a great practical use as a guideline for manufacturers and regulators to properly develop and regulate the use of these novel green solvents.

HYDROLYTIC DEHALOGENATON OF BENZALDEHYDE-DERIVED γ-LACTONES

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KEYWORDS:
biotransformation, halolactones, hydrolytic dehalogenation

Lactones are cyclic esters of hydroxyacids. These compounds and their derivatives are not only the products of chemical synthesis, but can also be found in the natural environment. The halolactones contain both lactone ring as well as halogen atom. Those compounds exhibit a wide spectrum of biological activities like anticancer [1,2], deterrent [3,4], antifungal [5] or anti-inflammatory [6]. Taking into consideration their possible applications, it is essential to identify the halolactones degradation pathways in the environment. Microbial transformations of halolactones can serve as the model processes to investigate their metabolism in living organisms. Further, the biotransformations are useful tool to obtain derivatives with additional functional groups. These structural modifications can be crucial for intensification or change the biological activity.

Many examples of lactones biotransformation can be found in the literature, but there are only few reports about the microbial dehalogenation of those compounds. The main aim of this work were microbial transformations of three benzaldehyde-derived γ-lactones containing the iodine, bromine or chlorine atom. The biotransformation processes were carried out using whole-cell cultures of fungi as the biocatalysts. Among 10 tested strains nine of them were able to transform the halolactones, but only Absidia glauca AM254 transformed all three halolactones in high yields. The selected strain catalyzed hydrolytic dehalogenation and in all cases the corresponding hydroxylactones were obtained as the only products. The optimal biotransformation period as well as chemical structure and enantiomeric excess of the products were determined.

POULTRY SLAUGHTERHOUSE AND MEAT PROCESSING WASTEWATER TREATMENT PLANT

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KEYWORDS:
biological wastewater treatment, polutry slaughterhouse wastewater

Industrial wastewaters can pose a serious environmental problem if not properly treated before their discharge into natural recipient, e.g. small river, lake or even soil. Slaughterhouses and meat processing plants generate high strength wastewater, characterized by having an elevated concentration of organic matter (COD, BOD), nutrients (N and P), fats, oils and greases. Usually employed operations used for the treatment of this wastewater include mechanical pretreatment, equalization of wastewater, chemical treatment coupled with physical processes (e.g. flotation) and biological treatment used for further reduction/removal of organic pollutants and nutrients from wastewater. Wastewater treatment plant (WWTP) MADI combines all the above-mentioned processes in order to achieve required level of treated water before discharge into the river Tešanjka. Regeneration –Denitrification - Nitrification (R-D-N) type of biological reactor using activated sludge is used, which allows more stabilized work, effectively increasing the sludge age and high efficiency of N removal. By combining the chemical and physical processes (DAF Flotation with dosing of chemicals) and R-D-N reactor, WWTP MADI reduces all the wastewater quality parameters (including nutrients) below the required limit, regardless the loading variations during the day.

USING ECOREMEDIATIONS FOR PROTECTION OF HYDROELECTRIC POWER PLANT ACCUMULATION BASINS FROM POLLUTION

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KEYWORDS:
accumulation basins, ecoremediation, eutrophication, protection of water bodies, Sava River

Damming of rivers for the purpose of generating electricity causes major changes that significantly alter the ecological status of the watercourse. Newly created accumulation basin has a negative impact on various components of the environment, from habitat loss to changes in the hydrology of rivers and groundwater levels, which may increase the effects of pollution. Longer water retention time and reduced self-cleaning ability of reservoirs causes the occurance of eutrophication, which results in excessive growth of algae and macrophytes due to increased inflow of nutrients (N, P) from waste waters and agricultural run-off. This causes reduction of water quality and changes of living conditions.

Due to problems caused by eutrophication in accumulation basins on Sava river, a need for studies arose. Limnos Ltd. from Slovenia conducted several studies in which they proposed ecoremediation (ERM) measures to prevent or to mitigate the negative effects of eutrophication on accumulation basins upstream to the hydropower plant construction. A review of existing monitoring data showed an increased eutrophication in all accumulation basins, leading to the occasional appearance of the algal bloom. The aim of the studies was to highlight the pollution sources and suggest ERM measures to improve water quality in reservoirs.

The results that Limnos gained in the studies of hydropower plants area of Zbilje, Mavčiče, Boštanj and Blanca, and future accumulations at Brežice and Mokrice and in their catchments, showed that the biggest polluters are wastewater treatment plants (WWTP) and agricultural run-off. Bigger WWTP, not having tertiary treatment level, represent significant source of nutrients (especially phosphorus). As for nitrogen, the main pollution comes from non-point sources (run-off) from agriculture.
The most effective ERM measure to restrain excess nutrient and sediment run-off are constructed wetlands for treatment of domestic waste waters, and vegetation barriers. Constructed wetlands can in average remove 30–40% of nutrients from waste waters. With the addition of other materials effectiveness can be improved up to 90%. On the other hand vegetation barriers, which most successfully retain and bound sediment and nutrients from agricultural run-off, can achieve 50–90% removal for nutrients and sediment retention.

ERM are ecologically, economicaly, and sustainably, one of the most successful ways to protect the waterbodies from pollution and therefore eutrophication. ERM belong to green or ecosystem technologies. They are biotechnological methods that use natural and sustainable processes and systems for protection, rehabilitation of environment, cleaning and conservation of water.

PERFORMANCE OF LABORATORY-SCALE CONSTRUCTED WETLAND FOR DEGRADATION OF SODIUM DODECYLBENZENESULFONATE

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KEYWORDS:
phytoremediation, sodium dodecylbenzenesulfonate, Spirodela polyrhiza

The use of natural remediation methods to remove contaminants from wastewater is becoming more popular. This study specifically attempted to determine the viability for using wetland plant *Spirodela polyrhiza* (Lemnaceae) to remediate water contaminated with sodium dodecylbenzenesulfonate (SDBS). The studied species is aquatic plant widespread throughout the world in a wide variety of water bodies and faces no major threats. The study was carried out at the level of laboratory-scale constructed wetland containing mature plants of *Spirodela polyrhiza*. Plants grown in an aquaria for experimental purposes were exposed to 5 mg/L concentration of SDBS. The experiments were performed in the absence of nutrients. Two different controls were carried out in parallel: plants in a SDBS free medium and medium containing SDBS, but free of plants. The aqueous culture media was sampled (15 mL) every 24 h for SDBS analysis. In order to determine the amount of anion surfactant, MBAS method employing UV/Vis spectrophotometer Shimatzu in 652 nm wavelength was used. The test kit LCK 414 for Chemical Oxygen Demand (COD) measurements was used for monitoring of water quality. The amount of chlorophyll and carotenoids in plant leaves was measured spectrophotometrically in order to estimate stress level in plants. This study demonstrated that *Spirodela polyrhiza* could be considered as appropriate plant species for potential application in phytoremediation.

COMPARATIVE STUDY OF BASIL OIL AND LINALOOL AS GREEN CORROSION INHIBITORS

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KEYWORDS:
adsorption, corrosion, gravimetric measurements, green inhibitors, thermodynamic parameters

Among numerous compounds that have been tested and applied industrially as corrosion inhibitors, those that are non-toxic are now far more strategic than in the recent past. Furthermore, these green corrosion inhibitors except non-toxicity must have good inhibition efficiency. The exploration of natural products of plant origin as inexpensive green corrosion inhibitors is an essential field of study, because they possess molecules with electron-rich atoms, multiple bonds or aromatic rings which can act as adsorption centres. One of the well-known and frequently used aromatic herbs in Mediterranean region is basil *(Ocimum basilicum L.)*. Essential oils isolated from *O. basilicum L.*, can be classified in four major basil essential oil chemotypes: methyl chavicol-rich, linalool-rich, methyleugenol-rich, methyl cinnamate-rich, and numerous subtypes. The aim of this work is to investigate the essential oil of basil *(Ocimum basilicum L.,* chemotype linalool) and its main component, linalool as green inhibitors of the aluminium corrosion in acidic medium. The study was done by gravimetric measurements on different temperature range. Considering that inhibition efficiency of the plant extract vary with concentration, temperature, period of immersion and pH of corrosive medium, adsorption behavior of investigated compounds was obtained, and some thermodynamic and kinetic parameters were calculated, too.

INFLUENCE OF IONIC STRENGTH ON LIPASE IMMOBILIZATION ON EUPERGIT CM

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KEYWORDS:
biodiesel, enzyme retention, Eupergit CM, immobilization, Thermomyces lanuginosus lipase

Lipases produces by fungi, yeasts and bacteria have found wide application in industrial scale production of fine chemicals. Besides, they have been found applicable for biodiesel synthesis. However, their use for industrial scale biodiesel production is still in the process of research. The main obstacle for industrial scale implementation is high cost of enzyme due to inability of reuse and/or enzyme stability. This can be improved by use of immobilized enzymes. Therefore, this research investigated immobilization of *Thermomyces lanuginosus* (TLL) lipase on solid support Eupergit CM. Covalent binding of TLL on Eupergit CM was performed in the presence of phosphate buffered saline (PBS; pH = 7.5) at three different concentrations 0.01, 0.1 and 1 M, during 12 and 24 hours at 25°C. Immobilization efficiency was monitored by determination of protein concentration in filtrates remained after immobilization. The maximal enzyme retention on solid support, Eupergit CM, was achieved by use of 1M phosphate buffered saline after 24 hours, where 97% of proteins were found covalently bound on Eupergit CM, but significant amount of enzyme (92%) was also found after 12 hours of immobilization. Use of phosphate buffered saline of lower ionic strength resulted with significantly lower enzyme retention. Obtained results indicate importance of ionic strength for immobilization of *Thermomyces lanuginosus* lipase on Eupergit CM.

UTILIZATION OF MALTOSE IN LACTIC ACID PRODUCTION BY *Lactobacillus amylovorus* DSM 20531^T

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KEYWORDS:
bioreactor experiments, Lactobacillus amylovorus, maltose metabolism

Strains of species *Lactobacillus amylovorus* possess extracellular amylolytic activity that is essential for their accomodation in natural niches. In our comprehensive investigations strain *Lactobacillus amylovorus* DSM 20531^T was employed for hydrolysis and fermentation of starch as sole carbon and energy source. HPLC analysis have shown that starch was degraded to maltose and maltodextrins, while glucose was not detected during the bioprocess.
The aim of this work was to characterize the utilization of maltose for production of D-/L-lactic acid by *L. amylovorus* DSM 20531T at laboratory scale. Initial concentration of maltose was 20.0 g/L and fermentation was carried out at 40°C. The maltose was not completely depleted from the medium over 24.0 h of the bioprocess and substrate to product conversion coefficient ($Y_{P/S}$) of only 0.87 g of D- and L-lactic acid (in equimolar amounts) per g of spent maltose was achieved. No other fermentation products were observed in explored experimental conditions, although this strain was reported to produce small amounts of acetate at low sugar concentration.

SUPERCRITICAL CO_2 EXTRACTION AND HYDRODESTILLATION OF *Helichrysum italicum* FLOWERS

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KEYWORDS:
GC-MS profiles, Helichrysum italicum, hydrodestillation, supercritical CO_2 extraction

The increasing popularity of Immortelle *(Helichrysum italicum* (Roth) G. Don) and its products, particularly in cosmetic industry, is evident nowadays. Supercritical CO_2 (SC-CO_2) extraction is considered as promising alternative to the conventional solvent extraction in food, pharmaceutical and cosmetic industry due to the absence of solvent residue in extracts and better retention of aromatic compounds. SC-CO_2 extracts of H. *italicum* are free of organic solvent residues and suitable for direct use in cosmetic industry. SC-CO_2 extraction of H. italicum flowers in this study was performed at different process parameters of pressure and temperature. Hydro wdestillation was performed to obtain essential oil. The extracts were analysed by GC-MS and tremetone derivatives dominated: bitalin A, 12-acetoxytremetone, gnaphaliol, 1-[2-(2-methyl-2,3-dihydroxypropyl)-2,3-dihydro-1-benzofuran-5-yl]ethanone, isobutyl bitalin A and 1-[2-(acetylprop-1-en-2-yl)-3-hydroxy-2,3-dihydro-1-benzofuran-5-yl]ethanone. Striking differences were found among the essential oil and SC-CO_2 extracts composition. The major oil compounds were γ-curcumene, α-pinene, β-selinene, α-selinene and limonene. Mono- and sesquiterpene were found among minor constituents of the extracts. Neryl acetate was present in the extracts and essential oil.

HIGH HYDROSTATIC PRESSURE EXTRACTION OF POLYPHENOLS FROM TOMATO WASTE

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KEYWORDS:
high hydrostatic pressure extraction, polyphenols, tomato waste

During tomato processing a considerable amount of waste, composed of peel, seed and small amount of pulp is generated. Usually, these by-products are disposed in landfills and only partially reused by-composting or drying for animal feeding. Nevertheless, modern eco-compatible technologies offer more efficient strategies to recycle these wastes in order to use them as a sustainable source for the extraction of different biologically active compounds, such as polyphenols. To the best of our knowledge, no research has been done on the extraction of polyphenols from tomato waste by high hydrostatic pressure (HHP).

Therefore, this work reports methodology of polyphenols extraction by HHP from tomato canning industry waste at various experimental conditions, i.e. solvents (water, hydrochloric acid and methanol), solvents ratio, *v/v* (1 % HCl, 50 and 70 % methanol with and without addition of 1% HCl), temperatures (25, 35, 45 and 55°C) and holding times (5 and 10 min). The isolated polyphenols were evaluated in terms of total phenols (TP) and total flavonoids (TF) content, determined by a photometric Folin-Ciocalteu and aluminium chloride assays. TP and TF mass fractions were expressed as mg of gallic acid and rutin equivalents per g of dried tomato waste, respectively.

The results indicate that at steady pressure of 500 MPa, parameters such as temperature, type of solvent, as well as solvent ratio has a significant effect ($p<0.05$) on TP and TF contents. The highest mass fractions of these compounds were obtained at temperature of 45 °C with water and 50 % methanol as extracting solvents. Under such conditions, the mass fractions were found to be 49.7 and 43.3 mg/g for TP and 1.66 and 1.43 mg/g for TF, in water and 50 % methanol extracts, respectively. Other extraction parameters such as increases of extraction time from 5 to 10 min or addition of 1 % HCl to the organic solvents (50 and 70 % methanol) had no significant effect ($p<0.05$) on TP and TF contents.

Therefore, this preliminary investigation showed that HPP procedure is suitable for fast extraction of polyphenols from waste derived by tomato canning industry. In addition, the exploitation of these bioorganic residues will not only solve the problems of waste disposal, but also meet the requirements of polyphenols as a food supplement. In further work the use of mixture of water and other organic solvents, such as ethanol, acetone and acetonitrile as environmentally acceptable systems, will be investigated too.

APPLICATION OF PECTIN ISOLATED FROM TOMATO WASTE AS POTENTIAL TIN CORROSION INHIBITOR

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KEYWORDS:
Corrosion inhibitor, NMR spectroscopy, Pectin isolation, Rheology, Tomato waste

The possibility of utilizing the tomato waste from canning factory as a cheap source for pectin isolation and its application as a corrosion inhibitor was investigated to implement viable cyclical economy principle in solving the main problem of waste disposal.

Pectin, from two tomato waste, batches A and B was extracted with ammonium oxalate/oxalic acid (under reflux), during 24 h in the first step, and then again with a fresh volume of extracting agent during 12 h in the second step.

The isolated pectins were evaluated by characterisation of its physical properties, i.e. colour and viscosity. Subsequently, the sample with better rheological behaviours, i.e. pectin obtained from tomato peel batch A (A-I) was examined as corrosion inhibition substances of pure tin by electrochemical potentiodynamic analysis. The measurement was carried out in a mixture of 2% NaCl, 1% acetic acid and 0.5% citric acid, at 25 °C in absence and presence of different concentrations (0.2 - 4.0 g/L) of A-I pectin. To compare the corrosion inhibition efficiency of this pectin, commercially available apple pectin (CAP) was analysed, too. In addition, the structure of pectin samples used in corrosion test was characterised by NMR spectroscopy.

The results indicate that conducted extraction steps have shown a different effect on the viscosity and colour of pectin. The viscosity of brown coloured pectin samples (first step) was higher than viscosity of white coloured pectin samples (second extraction), which mean that each extraction step has a considerable influence on pectin gel properties, such as appearance, gel formation and strength. Corrosion results point out that pectin is efficient inhibitor (73%) even at very low concentrations, much better then CAP (60%). By addition of A-I to the tested solution, the change in the mechanism of corrosion process and an improvement in corrosion behaviour are obvious. This could be explained by physical adsorption process of pectin molecules via carbonyl, carboxylic and ionic carboxyl groups presented in galacturonate and methyl galacturonate units of A-I (confirmed by NMR experiment). These negatively charged groups could electrostatically bind positively charged tin ions, preventing further tin corrosion in aggressive medium by the formation and precipitation of complexes at the tin surface as a physical barrier.

Therefore, this investigation points out that tomato peel waste could be used as a promising industrial resource for pectin production and its application as tin corrosion inhibitor, instead of ordinary chemical and toxic inhibitors.

EXTRACTION OF PHENOLIC COMPOUNDS FROM COMFREY ROOT BY GREEN TECHNIQUES

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KEYWORDS:
comfrey root, green techniques, phenolic content, Symphytum officinale
Authors prefer poster presentation.

A strong movement towards utilization of green and environmentaly friendly techniques stimulated the development of supercritical fluid (SFE) and pressurised hot water (PHWE) extraction techniques. In addition to green character of these solvents, faster and more selective processes, reduced energy consuption and the low degradation of target compounds are just some of the benefits that contribute to better recovery of bioactive compounds from diverse plants by pressurised fluids. The root of comfrey (*Symphytum officinale* L.), a traditional medicinal plant, is a good source of bioactive compounds including not only antioxidant polyphenols, but also vitamins, minerals and allantoin. Frequent use of this plant in traditional medicine has recently drawn much attention of the scientific community. The extraction of phenolic compounds from comfrey root using supercritical carbon dioxide and pressurised hot water has not been widely studied. The aim of this work was to investigate the SFE and PHWE techniques for the isolation of phenolic compounds from comfrey root. Pressurised hot water extraction was carried out at different temperatures (60-170 °C) and pressures (30-100 bar). The PHWE results were compared to those obtained by SFE using supercritical CO2 modified with ethanol, at different pressures (150 and 300 bar) and modifier percentage (7 and 15%), while other parameters were constant. The obtained extracts were characterized in terms of total phenolic content (TPC) determined using Folin-Ciocalteu procedure. Determined PHWE conditions which provided the highest TPC (301.49 mg GAE/g sample) included extraction temperature of 130 °C and pressure of 60 bar at the extraction time of 30 min. On the other hand, the SFE experiments showed that the maximum TPC (12.19 mg GAE/g sample) was attained under the following conditions: pressure of 300 bar and modifier percentage of 15%, at the extraction time of 2 h. The results made it clear that efficiency of pressurised hot water extracts was remarkably superior to that obtained by supercritical CO_2 in terms of phenolic content, even though the performance of CO_2 extraction was improved with the addition of ethanol as a modifier.

OPTIMIZING OF SWEET WHEY ULTRAFILTRATION AT 25°C AND 40°C

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KEYWORDS:
concentration factor, membrane, ultrafiltration, whey, whey proteins

Whey has excellent nutritional value, mostly due to whey proteins which are also characterised by excellent functional properties. Ultrafiltration enables the concentration of whey without applying high processing temperatures which in turn results in obtaining native whey protein concentrates with fully preserved nutritional and functional properties. The main disadvantage of membrane processes including ultrafiltration is the phenomenon of membrane fouling which largely influences process efficiency.

Hence, the aim of this work was optimizing whey ultrafiltration at two different temperatures, more precisely at 25°C and at 40°C. Thereat several factors which determine ultrafiltration efficiency were optimised and investigated with the optimal transmembrane pressure and the flow inlet of whey through the module being among the most important ones. After preliminary experiments, regardless of the process temperature two regimes of transmembrane pressure and flow inlet were chosen - 0.8 bar and 0.6 L/min and 1.2 bar and 1 L/min respectively. Subsequently, whey was subjected to ultrafiltration at those specific conditions and the obtained whey concentrate composition was analysed. The highest factor of concentration (5.73) was achieved at 40°C and at higher flow inlet and transmembrane pressure in comparison (0.6 L/min and 1.2 bar and 1 L/min) and was followed by the concentration factor (5.17) achieved at 25°C and the same processing conditions. Membrane fouling was significant at both temperatures and regimes, but was somewhat lower at milder processing conditions i.e. 0.8 bar and 0.6 L/min. The contents of components other than proteins (lactose, fats, dray matter and minerals) in the obtained concentrates were approximately the same regardless of the applied processing conditions. Regarding all of the obtained results the most appropriate regime for ultrafiltration of sweet whey appeared to be at 40°C and 1.2 bar and 1 L/min.

DEEP EUTECTIC SOLVENT [CHOLINE-CHLORIDE – GLYCEROL, 1:1.5] AS A SELECTIVE EXTRACTANT FOR LIQUID FUEL DENITRIFICATION

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KEYWORDS:
[choline-chloride – glycerol, 1:1.5], deep eutectic solvent, denitrification, extraction, liquid-liquid equilibria

Deep eutectic solvents (DESs) are considered as ˝green˝ replacement for hazardous industrial volatile organic solvents owing to their great physical and chemical properties. Low melting point, negligible vapor pressure, non-flammability, reuse, easy and cheap synthesis from non-toxic and biodegradable compounds make DESs attractive enough to take place in different fields of application. In this work the potential of DES [choline-chloride – glycerol, 1:1.5] for denitrification of a model fuel by means of liquid-liquid extraction is investigated. The model fuel solution consisted of *n*-heptane, *n*-hexane, *i*-octane, toluene and pyridine. The tie lines of the liquid-liquid equilibria for the ternary systems DES – *n*-heptane/*n*-hexane/*i*-octane/toluene – pyridine were experimentally determined at 25 °C and atmospheric pressure. The equilibrium data in ternary systems were described with NRTL and UNIQUAC models. The complete characterization of investigated DES with respect to refractive index, pH value, thermal conductivity, thermal diffusivity, thermal capacity, electrical conductivity, density and viscosity was performed as well at 25 °C and atmospheric pressure. The extraction efficiency shows similar values in the systems involving *n*-hexane, *n*-heptane and *i*-octane (~ 60 %) which is higher than the value found in the system comprising toluene (~ 43 %). Based on the obtained results it can be concluded that investigated DES can be considered as a potential solvent for fuel denitrification.

INFLUENCE OF HIGH POWER ULTRASOUND AS GREEN TECHNOLOGY ON WINE QUALITY

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KEYWORDS:
aroma, high power ultrasound, phenolic compounds, red wine, sensory analysis

High power ultrasound (HPU) has entered the field of food science and technology as non-thermal technology offering new opportunities for managing food quality. However, very few researchers studied the possibilities of HPU in controlling biological stability of wine and benefits of its use as "green" alternative to reduce sulfites, as well as HPU impact to overall wine quality. In addition, more attention is needed in the selection of HPU process parameters that will be both effective and preserve sensorial characteristics of wine. The aim of this study was to investigate the effect of different HPU treatments on the sensory and chemical quality of wine and to select the HPU process parameters sustaining wine quality. Three different wines including Cabernet Sauvignon, Merlot and Plavac mali were treated with HPU were variations in amplitude (20, 30 and 40%), treatment duration (2, 4 and 6 minutes) and probe tip size (12.7 and 19 mm) were applied. Effect of HPU treatment on wine quality was first evaluated by sensory analysis of trained panel group using 9-point hedonic scale. Chemical analysis was conducted on selected wine samples, after the sensory analysis was performed. Total polyphenols, anthocyanins and chromatic characteristic were analyzed by spectrophotometry, while free anthocyanins were analyzed by HPLC analysis. Wine aroma compounds were analyzed by GC analysis. The results obtained showed differences among treatment applied, where amplitude as well as probe tip size affected the overall characteristic and wine quality.

MEMBRANE AND REACTOR SYSTEM AS A CONTRIBUTION TO PROCESS INTENSIFICATION STRATEGY

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KEYWORDS:
membrane technology, process intensification, reactor engineering

In this paper an overview of membrane and reactor technology application in water and food sector according to process intensification principles was presented. Process intensification strategies are based on innovative equipment, design and process development methods, which will improve manufacturing and processing aspects through decreasing raw materials utilization, energy consumption, production cost, equipment size and waste generation.

In many strategic sectors such as water, food, energy, health, etc. the necessary transformations will take place consistently with the process intensification principles. Advanced technologies which include membrane and reactor systems, e.g. advanced oxidation processes (AOPs) and/or membrane bioreactor (MBR), are essential to enable a better use of existing resources along the whole life cycle to develop new production and recycling paths. The selection of the treatment process(es) and membrane(s) for purification depends on the origin and characteristics of processed streams and the aims that have to be reached by the overall treatment. Different types of membranes and reactor systems can be easily combined in economic hybrid systems that permit free adjustment of product parameters and energy use, save raw materials, minimize energy consumption and allow realizing various recovery strategies.

RECYCLING OF FOOD FACTORY BY-PRODUCTS: SUBCRITICAL WATER EXTRACTION OF ARONIA FRUIT DUST

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KEYWORDS:
antioxidant activity, aronia, optimization, subcritical water extraction

In the recent few years aronia (*Aronia melanocarpa* L.) has gained a huge interest due to its unique composition of bioactive compounds that ensures multiple health-promoting. It was found that aronia is one of the richest herbal sources of phenolic compounds and that the content of proanthocyanidins, anthocyanins and phenolic acids in this herb is quite high. Compared to the other fruits, antioxidant activity of aronia is significantly higher. Positive effect of aronia has been noticed in the case of: control and prevention of diabetes mellitus type II, the prevention and treatment of cardiovascular diseases, protective effect on colon cancer etc. During the production of aronia fruit filter tea, in filter tea factory aronia cake (obtained from juice production in the juice factory) is milled, grind and fractionated. After processing certain amount of such material, approximately 20%, is of particle size lower than the particle size of pores of filter tea bag. This material is called ''fruit dust'' and represents by-product of this industrial branch.

In this study "aronia fruit dust" has been utilized for the production of liquid extracts by application of powerful green extraction technology – subcritical water extraction. In the process of subcritical extraction influences of three different process parameters were observed: temperature (X_1: 120 – 220 °C), extraction time (X_2: 10 – 30 min) and HCl concentration (X_3: 0 – 1.5 %). In obtained liquid extracts, content of total phenolic compounds was in the range from 1.32 to 2.95 mg GAE/ml of extracts, content of total flavonoids from 0.42 to 2.16 mg CAT/ml, while content of total anthocyanins varied from 0.0041 to 0.3138 mg/ml. Antioxidant activity was determined using DPPH test and it ranges from 0.21 to 1.43 µl/ml. Obtained results were mathematically analyzed using Response Surface Methodology.

ISOLATION OF ANTHOCYANINS FROM GRAPE POMACE BY NATURAL DEEP EUTECTIC SOLVENTS AND VALORIZAION OF ITS BIOLOGICAL ACTIVITY

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KEYWORDS:
anthocyanins, deep eutectic solvents, grape pomace, human cell lines, in vitro biological activity, macroporous resin

Natural deep eutectic solvents (NADES) are a new generation of environmentally friendly solvents with possible applications in various industrial fields. NADES are mixtures of two or three cheap and readily available components, such as nontoxic quaternary ammonium salts (e.g., cholinium chloride) and naturally-derived uncharged hydrogen-bond donor (e.g., vitamins, amines, sugars, alcohols and carboxylic acids). Those solvents are commonly composed of cellular metabolites in specific molar ratios, including water in some cases, and are characterized by strong intermolecular interactions (eg. hydrogen and ionic bonds). Furthermore, eutectic solvents have unique physical and chemical characteristics, and with regard to the possibility of designing their structures, it is possible to rationally design them for specific purposes. One of the application areas of NADES is the extraction of bioactive compounds from plant materials. NADES have been reported as extraction agents for phenolic compounds due to their ability to form hydrogen bonds between the phenolic compounds and DES molecules.

Based on the above mentioned, the aim of our research was extraction of anthocyanins from grape pomace by using NADES and its isolation while preserving their biological activity. Grape pomace extracts were prepared with five different NADES in an ultrasonic bath. Anthocyanins from extracts were isolated by macroporous resin Amberlite XAD-16 and eluted with ethanol. Ethanol eluents were analysed and total content of anthocyanins and its antioxidant capacity was determined. Biological activity of anthocyanins in ethanol eluents was valorised in vitro by testing their impact on three cell lines (HeLa, MCF-7, and HEK293T). The developed procedure for isolation of anthocyanins based on extraction with NADES in combination with application of macroporous resin could be good alternative and environmental method for the extraction and enrichment of anthocyanins from grape pomace.

NATURAL DEEP EUTECTIC SOLVENTS – ANTIMICROBIAL AND CYTOTOXIC ACTIVITY

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KEYWORDS:
antimicrobial activity, cytotoxicity, natural deep eutectic solvents

Development of green technologies is highly devoted to designing new solvents with good ecotoxicological profile, low cost and desirable technological properties. Natural deep eutectic solvents (NADES) are a new generation of novel alternative solvents. They are mixtures of two or three compounds such as choline chloride, as the cationic salt, and alcohols, acids, amides, amines or sugars as hydrogen-bond donors. NADESs are often presumed to be non-toxic due to natural origin of their constituents, but the evaluation of their toxicity and biodegradability must accompany the research on their synthesis and application. The most of the work reported in the current literature was done on the bacteria and some fungi, while there are only a few scientific papers publishing results on cytotoxicity of NADESs toward cell lines. Differences in toxicity response between bacteria and cell lines were observed. Most likely, the mechanism of NADES action is associated with its interactions with the cell membranes and therefore could be species-dependent.

In the work presented in here we investigated the effect of ten synthesised NADES toward bacteria (*Escherichia coli, Proteus mirabilis, Salmonella* sp., *Pseudomonas aeruginosa, Staphylococcus aureus*), yeast *Candida albicans* and human cell lines (HEK293T, HeLa and MCF-7). Amongst all bacteria evaluated by filter paper diffusion assay, the highest inhibition zone was measured toward Proteus mirabilis, while inhibitory effect was not observed on *Candida albicans*. Between tested NADESs, high inhibition towards all tested bacteria and yeast was observed with choline chloride:oxalic acid (Ch:OX) and was followed by NADES who also have acidic group as hydrogen-bond donors (malic acid and citric acid). Cytotoxicity toward HEK293T, HeLa and MCF-7 cells was determined by MST assay in the range of concentrations (500 mg ml^{-1} to 2000 mg ml^{-1}). The highest inhibitory effect on cell growth was observed with Ch:OX which possess moderate cytotoxicity. Other NADES did not caused 50% of growth inhibition in the range of tested concentration so the IC_{50} value was declared to be > 2000 mg ml^{-1} *i.e.* > 5 mM meaning that they possess low cytotoxicity.

Overall, our results indicate that is not a good approach to *a priori* consider NADESs as harmless solvents, simply because most of their forming compounds are benign for humans and the environment. Due to the enormous chemical diversity and huge number of possible combinations, careful and critical assessment of the environmental impact, at least of those NADESs that are likely to have technological application, is needed.

Session D:

BIOMASS FOR BIO-BASED ECONOMY

CHARACTERISATION OF HYDRODYNAMIC CONDITIONS IN 3D PRINTED MICROREACTOR: APPLICATION IN DYES DECOLONIZATION

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KEYWORDS:
hydrodynamic characterization, microreactor performance, PolyJet matrix 3D printed microreactor

Hydrodynamic characterisation of microreactor systems is important for the microreactors application and construction improvement and it can be used for the prediction of system behaviour. Pressure drop and Reynolds number was determined in the wide range of process conditions (residence time 60-7.5 s, the flow rates 0.2-2.0 ml min-1 and microreactor length 1-100 cm). Pressure drop increase with the microreactor channel length and flow rates incensement and it was in the ranging between 25.50 and 142.16 kPa m-1. Significant changes of pressure were observed in the last section of microreactor. Reynolds number was in the range of 7-127. Hydrodynamic condition was characterised by dispersion model. The obtain Bodenstain numbers were in the range of 150-600. Using simple criteria for microchanels hydrodynamic characterisation and experimental results plug-flow conditions with the relatively small axial dispersion determine hydrodynamic properties in the constructed microreactor. These characteristics can be used for the appropriate microreactor application and enhancement of microreactor performance. In the introduction some example of the different 3D printing technologies will be overview and advantages of PolyJet matrix 3D printing Multi-Material Technology apostrophized as promising one for microreactor manufacturing.

LIPID PRODUCTION FROM LIGNOCELLULOSIC BIOMASS BY YEAST *Trichosporon oleaginosus*

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KEYWORDS:
biodiesel, lignocellulose, microbial lipids, oleaginous microorganisms

Biodiesel is a renewable substitute fuel for traditional petroleum-based diesel. It consists of the methyl esters of the fatty acids produced by trans-esterification of triglycerides with an alcohol such as methanol under mild conditions in the presence of a base catalyst. Main feedstocks used for commercial production of first generation biodiesel are plant oils (rapeseed, soybean, palm, sunflower), animal fats and waste oils. Compared to petroleum diesel, biodiesel is less toxic, biodegradable and does not contain sulphur or aromatics. Despite these benefits, the major obstacle to widespread commercialization of biodiesel production is the high production cost relative to petroleum diesel. The high price of the feedstock is the major factor determining the biodiesel price. Intensive search for alternative feedstock brought back in focus the microbial lipids. An oleaginous microorganisms have ability to accumulate significant amounts of lipids (>20% of dry matter) under certain cultivation conditions. Production costs could be significantly reduced by replacing expensive carbon sources (e.g. glucose) with low-value substrates such as agricultural wastes, food waste streams and industrial by-products.

In this work, oleaginous yeast *Trichosporon oleaginosus* was used for the production of lipids from corn cobs hydrolysate. Batch process of simultaneous saccharification and lipid production (SSLP) was conducted at different initial substrate loadings (5-20 % w/w). The highest final lipid yield of 92.4 mg lipid per g of dry matter of pretreated corn cobs (g/g_{DM_PCC}) was obtained at substrate loading of 12.5% (w/w). A "fed-batch" strategy of sequential loading of substrate during SSLP process was investigated to achieve high cumulative substrate loadings, reduce viscosity of lignocellulosic slurry and obtain higher lipid yields. Batch additions of 2.5 and 5% (w/w) substrate resulted in cumulative substrate loading of 20% (w/w). The strategy of gradual substrate addition was related to the homogenous medium conditions during bioprocess due to the more efficient mixing process. Fed batch process of SSLP with substrate additions of 2.5 % (w/w) significantly increased the lipid yield in comparison to the batch process. Maximal lipid yield of 269.25 mg/$gDM_{\_PCC}$ was obtained after 312 hours of cultivation.

POTENTIAL OF CORN COBS FOR PRODUCTION OF BIOFUELS AND BIOCHEMICALS

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KEYWORDS:
alkaline pretreatment, biotechnology, corn cobs, feedstock, lignocellulose

Corn cobs, which are available in large quantities in the continental Croatia, were subject of this work because they can be used as a readily available, renewable lignocellulosic feedstock for biotechnological production of biofuels, biochemicals and many other products. The effect of alkaline treatment on corn cobs composition was investigated, using gravimetric and spectrophotometric analytical methods. Portions of dry matter, ash, protein, extractive substances, lignin and cellulose were analysed in the starting raw material and compared with those obtained after treatment with sodium hydroxide. The results obtained for corn cobs were generally in line with the values reported in the literature, while minor deviations can be interpreted as the influence of genetic factors, growing conditions, modes of production and storage as well as the impact of the applied analytical methods. Portion of total lignin in the dry matter of corn cobs was 11.55% (10.02% and 1.54% of insoluble and soluble lignin, respectively). The share of total extract in dry matter of corn cobs after alkaline treatment was 1.26% (0.53% of water extract and 0.73% of ethanol extract). This treatment has removed a large part of lignin. The treated corn cobs contained 5.19% of the total lignin (2.46% and 2.73% of insoluble and soluble lignin, respectively) in the dry matter. At the same time there has been an increase of the portion of cellulose in the dry matter, with approximately 42.23% in the raw material to 74.38% in the alkaline treated feedstock. Portion of hemicellulose, calculated by subtracting other compounds from the total solids, were 39.00 and 18.52% for corn cobs and alkaline treated feedstock, respectively. Numeric indicators, applicable for comparison of variations in raw materials, as well as for monitoring of lignocellulose pretreatments and solid-state fermentation, have also been introduced in this work.

BIOSORPTION OF Cu^{2+} FROM AQUEOUS SOLUTION BY HYDROCHAR OF GRAPE POMACE

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KEYWORDS:
adsorption isotherms, copper removal, FTIR, grape pomace, hydrochar

Hydrothermal carbonization is a promising route for conversion of lignocellulosic biomass into biofuels, adsorbents and specific chemicals. Herein, the evaluation of grape pomace as a precursor to obtain hydrochar, an adsorbent of copper from wastewaters, using hydrothermal conversion was performed. By examining the effect of sorbent dose and contact time, the ability of grape pomace hydrochar to effectively remove copper from aqueous solutions was confirmed. The obtained adsorption isotherms were best described by the Langmuir model. FTIR analysis of samples before and after adsorption supports the proposed mechanism of metal binding onto hydrochar surface.

THE RUB RESISTANCE OF PRINTED INK ON PAPERS WITH VARIABLE CONTENT OF WHEAT PULP

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KEYWORDS:
Euclidean color distance, newsprint, rub resistance, wheat pulp

In European countries newsprint is predominantly made from recovered fibres, while other graphic papers contain considerably lower share of recovered paper. Newsprint is a lower grade paper because it has already been recycled numerous times, while other papers are categorized as higher grade papers. During recycling process fibre length become shorter and the length of the fibre defines the grade of paper. After five to seven cycles of recycling process, the fibres become too short for producing new paper and it is necessary to mixed them with virgin fibres. As the demand for paper products nowadays is still high, different types of conifers and deciduous trees become insufficient raw material for paper production. This lack of raw material is the result of irrational exploitation of the natural resources for different purposes (lumber, heating material, pulpwood). Therefore, the utilization of alternative sources of virgin cellulose fibres as agricultural residues, whose potential is not sufficiently exploited, is of great importance for papermaking industry. The idea is how various field crop species could represent an alternative to using hardwoods in some lower grade papers and graphic products as newsprint ie newspaper. The aim of this research was to explore the reproduction quality of printed laboratory papers made of variable content of wheat pulp. The reproduction quality of prints was observed through rub resistance analysis. The rub resistance tests were made 6 and 24h after printing. Analysed papers were printed with carbon black ink by Prufbau Printability Testing Machine, which simulates coldset offset printing process. The reproduction quality of the prints before and after rub resistance tests were analysed by spectrophotometric values (L*a*b*). Based on provided measurements the Euclidean colour difference, ΔE_{00}*, was calculated. The results have presented how with the increasing the portions of wheat pulp in laboratory papers is achieved a better rub resistant. Wheat pulp provides good rub resistance of newsprint which means that the ink will not come off onto the reader's hands if wheat pulp will be used in commercial newsprint sector.

ECOPRESSWOOD - FORMALDEHYDE FREE BIO-BASED THERMOSETTING RESIN FOR WOOD PRESSED PRODUCTS

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KEYWORDS:
bio based, ecopresswood, formaldehyde free, wood panels

Pressed wood panels are composed of chopped or cut wood that are glued together using adhesives. Most of these resins are petroleum based products containing a hazardous chemical: formaldehyde. The acceptable levels of formaldehyde in wood pressed products have been reduced over the past decades due to increased public awareness on its effects on health and the consequent consumer demand for non-hazardous products.

The current situation in Europe is that the Committee for Risk Assessment of the European Chemical Agency has recommended reclassifying formaldehyde from category 2, "probably carcinogenic to humans" to category 1B "substance which is presumed to have carcinogenic potential for humans". This reclassification is expected by 2017 and it will surely have an impact on EU standards with regards to formaldehyde emissions from wood panels. In turn, this will affect the competitiveness of European woodworkers who will be forced to reduce, or even eliminate, the use of formaldehyde resins in wood panels.

The development of efficient renewable resins to substitute petroleum formaldehyde based adhesives is one of the biggest challenges for the Wood Industry.

To do so, the ECOPRESSWOOD project aims to develop "formaldehyde free" wood based panels that combine bio-based chemistry, nanotechnology and process engineering.

To be cost competitive and environmentally friendly, this new resin will be produced from residues of biodiesel production. The performance of the bio-panels will be increased by ceramic nanoparticles that will provide extra reinforcement. Moreover manufacturing processes will be researched to integrate both developments.

RESULTS FROM THE FIRST CROATIAN SRC POPLAR PLANTATION

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KEYWORDS:
ash content, biomass yield, harvesting, moisture content

Recent trends in the bioenergy sector development in Croatia highlight the raw material availability as one of the key factors that will define the prospect of future investments in bioenergy facilities. Therefore, it is logical to expect considerable investments in SRC plantations to overcome these near future challenges.

Main factors influencing the feasibility of SRC plantation are the biomass yield and properties of the produced raw material that affect the quality of solid biofuels. In this respect, research was conducted in one of the first SRC poplar plantations, established in the autumn of 2012 in Baranjsko Petrovo Selo by planting S1 and M1 poplar clones in spacing 2.8 m between the rows and 2.4 m inside the row (to leave open the possibility for transformation of SRC plantation to poplar forest plantation by thinning). In early spring of 2016, based on the DBH distribution, 6 trees of S 1 and 5 trees of M 1 clone were cut, measured and sampled for laboratory analyses of moisture content, wood/bark ratio, ash content and calorific value according to HRN EN ISO standards for solid biofuels. Results were processed by analyses of variance.

DBH (9.8 cm vs. 6.0 cm), height (11.3 m vs. 9.1 m) and biomass yield per tree (17.5 kg oven dry vs. 6.4 kg oven dry) differed statistically in favour of S 1 clone. Share of bark was also statistically different, 17.3% in the case of S 1 and 20.7% in M1 clone. Average moisture content (not statistically different) amounted 53.2% and pointed the need for optimizing the harvesting season or to consider natural drying opportunities. Great differences were found in ash content of bark (5.83% in S 1 and 5.96% in M1) compared to the ash content of wood (0.49% in S 1 and 0.53% in M1) and these results together with the share of the bark define the feedstock in terms of suitable end-user of appropriate solid biofuel produced. Additionally, due to the ash content differences the calorific value of the bark was 3% lower than the calorific value of the wood.
Results acquired by this research could be used in critical evaluation of the potential of SRC plantations to offset the already present shortage of the available biomass for energy in Croatia (in terms of expected yield and raw material quality) as well as to design suitable harvesting systems by adopting appropriate harvesting technology and supply chain management.

QUANTIFYING VOLUME OF COARSE WOODY DEBRIS IN FORESTS: COMPARISON BETWEEN TWO SAMPLING METHODS

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KEYWORDS:
fixed-area sampling, line-intersect sampling, lying deadwood, silvicultural treatments, volume

The term deadwood refers to all non-living woody biomass in a forest, either standing, lying on the ground, or in the soil and not included in the litter. In traditional forest management, deadwood is considered a potential source of biotic and abiotic disturbances and an obstacle to silvicultural activities. Recently, in the context of sustainable forest management, deadwood role as fundamental substrate for numerous rare and endangered species, key factor in carbon and nutrient cycles has been recognized. According to international literature, deadwood is an important forest ecosystem carbon pool because it reduces carbon dioxide (CO_2) emissions thanks to its slow decomposition rate (10-20% of total carbon storage in forests is in the deadwood carbon pool). Different silvicultural treatments (e.g. clearcutting, selective cutting, thinning) affect the deadwood quantity and influence the carbon sequestration in forests. LIFE FoResMit (LIFE14 CCM/IT/000905) project focuses on providing forest management good practices for increasing carbon sequestration and containing greenhouse gas emissions, and in this context the relationship between standing and lying deadwood volume and silvicultural treatments are analyzed. The aim of the research is to test two different methods for estimating the volume of lying deadwood in a case study in Italy (Monte Morello site). The methods used to estimate the volume of lying deadwood in the case study site are the following: the fixed-area sampling approach (FAS) and the line-intersect sampling one (LIS). The study area in Monte Morello site is situated on a calcareous substrate in Tuscany region and it is characterized by degraded forests of black pine (Pinus nigra J.F.Arnold) Brutia pine (*Pinus brutia* Ten. subsp. brutia) and cypress (*Cupressus spp.*). The volume of coarse woody debris was estimated using 18 fixed-area plots with a radius of 13 m (531 m²) and two LIS of 26 m of length. For each coarse woody debris in the fixed-area plot was measured length and diameters in two cross sections (minimum and maximum) and evaluated the decay class, while in the LIS was measured the diameters of the wood pieces at their points of intersection with the relative decay class. The results show that the average volume of lying deadwood using the fixed-area plots is 63.39 m³/ha, while using the LIS the average volume is found to be of 64.91 m³/ha. The non-parametric Wilcoxon test does not show statistically significant differences between the two methods.

FUEL CONSUPTION AND CO_2 EMISSION IN TIMBER HAULAGE ON DIFFERENT TYPES OF ROADS

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KEYWORDS:
CO_2 emission, fuel consumption, timber haulage, truck and trailer

Timber haulage is the last phase of timber harvesting. Due to its characteristics, cycle operation, a lot of unloaded driving, high purchase price of truck, transport of small amounts of goods, high fuel consumption, timber haulage is the most expensive phase of timber harvesting. Also timber haulage has a lot of negative impact on the environment due to its high greenhouse gas emission, especially CO_2 emission.

The aim of the paper is to analyze fuel consumption of forest truck and trailer during timber haulage in comparison to longidutinal slopes of roads, types of roads and total vehicle mass. Fuel consumption is measured by CANBUS module and data was transferred via Fleet manager system from truck to registred server. Fuel consumption is analyzed by overlapping the positions of truck from GPS signal with maps of public and forest road, in the aim to connect data with types and slopes of the road. Mass of the vehicle is measured with integrated scales on the air cushions on the truck and trailer. Research were performed on public and forest roads placed in mountanious and hilly regions. CO_2 emissions are calculated based on fuel consumption data on different slopes and types of road.

BLACKWOOD FROM SOFTWOOD TO HARDWOOD

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KEYWORDS:
Furan Resin, Hardwood, Softwood, Sustainability

Introduction: In the atmosphere of dry, clean air at steady temperature, wood can last forever. However, it is the changes in atmosphere that promotes decay of wood. Preservation of wood has a long history. In antiquity, people understood principles of dry distillation of wood and used creosote for wood preservation. Also, oils, waxes and resins. But all the outcomes were never significantly improved wood industrilised utilities. In our novel approaches we have revolutionised wood process from softwood to hardwood.
Aims: The World is well stocked with softwoods. Especially, from fast growing, well managed plantations. The initial idea was to find a suitable stock material and chemically modify it to enhance its properties.
Results: We have screened all commercially available softwoods and some hardwoods and the selection narrowed to Pinus radiata, that qualified to the criteria. Our treatment criteria are: 1) Reacting with wood to form a chemical bond; 2) Blocking cellulose hydroxyl groups to reduce affinity for water. 3) Form insoluble polymer inside cellular structure of wood Organic origin, a renewable resource. To achieve non-toxic Permanent bond, giving full protection against wood destroying bio agents, insects and fungi, Imparting fire retarding properties to the final product. The choice of treating resin stopped at furan type. We have synthesised 3FB (furfuryl borate, which we impregnated dried wood , containing catalyst from previous impregnation
Conclusions: compared with other timbers above Blackwood offers high durability, and stability which keeps the moisture within 5%, and has high MOE and MOR. With the controllable density, Blackwood is the best choice for outdoor and indoor material, can be widely used for construction structure, wooden houses, walkways, claddings, outdoor windows and doors, stairs, outdoor furniture, heated floor and other areas. Furthermore, we can adjust the appearance and color according to the surroundings and backgrounds to meet environmental requirements, and provide delightful visual effect.

THE USE OF BEVERAGE STORAGE POCKETS (Tetra Pak™) WASTE IN WOOD-PLASTIC COMPOSITES

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KEYWORDS:
mechanical properties, SEM, Tetra Pak™, WPCs

The use of Tetra Pak™ residues as filler or reinforcement in polymers is a prospective commercial application that would unlock the potential of these underutilized renewable materials and provide a non-food based market for these industry. In this study, the effect of Beverage Storage carton (Tetra Pak™) waste and maleic anhydride grafted polyethylene (MAPE) contents on the mechanical properties of wood-plastic composites (WPCs) were investigated. The proportion for wood flour and waste juice packets were (30, 10%), (20, 20%), (10, 30%) and the MAPE was chosen in two levels of 0 and 3%. First, the materials were prepared by melt compounding process in an internal mixer (Brabender® Plasti-Corder®), and then the samples were manufactured by injection molding method. The morphology of the specimens was characterized using scanning electron microscopy (SEM) technique. The results showed that when the contents of the Tetra Pak™ were increased from 0 to 30 wt%, the modulus and tensile strengths of the samples increased to 143% and 24.4%, respectively, and the sample without Tetra Pak™ and containing 3% of MAPE has the highest impact resistance. Also, SEM micrographs showed that by increasing Tetra Pak™, the mechanical strength is increased due to the presence of aluminum particles in the matrix. The presence of MAPE as a coupling agent leads to cohesion of the surface and prevents the development of cracks in the matrix. Generally, these results confirmed that the mechanical properties of LDPE/Tetra Pak™ waste composites could be significantly improved with an appropriate combination of the Tetra Pak™ and MAPE in the composites.

REMOVAL OF CONGO RED FROM AQUEOUS SOLUTION USING LIGNOCELLULOSIC BIOSORBENT AND SOLID STATE FERMENTATION OF DYE-ADSORBED BIOSORBENT

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KEYWORDS:
adsorptive removal, biosorbent, Congo red, decolourisation, T. versicolor

Brewers' spent grain (BSG), being the food industry lignocellulosic waste, was tested for its ability to adsorb azo dye Congo red (CR) from aqueous solutions. Effects of the initial dye concentration (30, 50, 100 and 150 mg L^{-1}), contact time, adsorbent concentration (5, 10, and 15 g L^{-1}), and pH (7, 8, 9 and 10) on dye removal were investigated. Dye removal was rapid within the first 60 min of the contact time. The percentage of dye removal increased with the increase in the adsorbent concentration and decrease in the initial dye concentration. The increase in pH caused reduction of the percentage removal. The percentage of CR adsorptive removal after 240 min contact time was over 85% for all runs. Dye-adsorbed biosorbent was further used as a substrate for solid-state fermentation (SSF) by the white rot fungus T*rametes versicolor* CCBAS AG613. Prior to solid-state fermentation experiment four white rot fungi strains, *Phanerochaete chrysosporium* CCBAS 570, T. versicolor CCBAS AG613, *T. versicolor* TV6 and *Ceriporiopsis subvermispora*, were screened for their ability to decolourise CR during cultivation (9 days at 27 ^{0}C) on agar plates containing dye at final concentrations of 50, 100 and 150 mg L^{-1}. Radial growth and the zone of colour change on agar plates were measured (at two perpendicular directions) every three days. Fungus T. versicolor CCBAS AG613 showed the highest decolourisation index (decolourization diameter/mycelial diameter) and was chosen for further SSF experiment. SSF of dye-adsorbed BSG (250 g BSG soaked in 350 mL of 150 mgL^{-1} dye solution) was carried out in a horizontal cylindrical glass flask at an ambient temperature. Temperature and weight were monitored on-line, while moisture, protein content, and colour of samples were measured after 7, 14 and 21 days of fermentation. Continuous protein content increase and weight loss were observed as a result of fungal growth and material biodegradation. Complete decolourisation of samples was not observed. However, colour determination showed the continuous increase of total colour change and colour intensity change of fermented samples, compared to their abiotic controls.

COMPOSITIONAL ANALYSIS OF LIGNOCELLULOSIC FEEDSTOCKS

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KEYWORDS:
corn cobs, corn husk, hay, hydrolysis, HPLC-RI, lignocellulose

Lignocellulosic biomass have been studied extensively as renewable carbon source for production of second generation of biofuels such as bioethanol and biodiesel. In order to determine the content of unfermented carbon source as well as overall efficiency of the process it is necessary to determine the content of lignocellulosic carbohydrates. Therefore, a simple and reliable method for the analysis of major lignocellulosic components (glucan, xylan and lignin) was developed. Composition of three abundant lignocellulosic feedstocks in Croatia, corn cobs, corn husks and hay, was analysed. Firstly, lignocellulosic biomass was subjected to sulphuric acid hydrolysis prior to monosaccharide determination. The acid hydrolysis was optimized to give the maximal constituent monosaccharides. A high-performance liquid chromatography (HPLC)-based method using refractive (RI) was applied to determine concentration of monosaccharides in purified lignocellulosic hydrolysate. Monosaccharides were separated by HPLC using two different HPLC columns, i.e. Rezex RPM Monosaccharide Pb^{2+} (Phenomenex) and Supelcogel C610H (Sigma-Aldrich). Glucan and xylane content was calculated from the HPLC measured cellulose (glucose) and hemicellulose (xylose, galactose, mannose, arabinose) derived sugars, respectively. Furthermore, the content of acid soluble and acid insoluble lignin in lignocellulosic hydrolysate biomass was also determined.

PRODUCTION OF CELLULASES AND HEMICELLULASES BY *Trichoderma reesei* ON CORN COBS

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KEYWORDS:
cellulases, corn cobs, hemicellulases, lignocellulose, Trichoderma reesei

Sustainable production of transportation biofuels and climate change due to GHG emissions represent the most important issues of the 21st century. Renewable and environmentally friendly advanced biofuels derived from lignocellulosic biomass are promising alternative to petroleum fuels. Production of biofuels involves two main steps: hydrolysis of cellulose and hemicellulose in lignocellulosic biomass to fermentable sugars and their conversion to biofuel by microorganism. However, production of alternative biofuels is still economically uncompetitive with fossil fuels. One of the most cost-effective steps in their production is enzymatic hydrolysis of lignocellulosic biomass due to the high cost of cellulases. Production cost of cellulases could be reduced using cheap lignocellulosic substrates for their production.

In the present study, cellulases and hemicellulases for lignocellulosic biomass hydrolysis were produced using semi-solid fermentation on corn cobs and microcrystalline cellulose as carbon source. The production of Trichoderma reesei cellulases and hemicellulases was carried out in shake flasks. After seven day of cultivation, cellulolytic activities produced on corn cobs (0.105 filter paper units /ml) were comparable with that on microcrystalline cellulose (0.125 filter paper units /ml). The cellulases and hemicellulases in culture filtrates were partially purified by precipitation with ammonium sulphate. The produced and commercial cellulases and hemicellulases were used for hydrolysis of pretreated corn cobs. The highest glucan (29%) and xylan (38%) conversion was obtained with commercial enzymes.

Session E:

ENVIRONMENT AND ECOSYSTEM SERVICES

WHICH ARE THE MAIN RISKS FOR MEDITERRANEAN FORESTS IN CROATIA AND HOW TO RESPONSE TO THEM

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KEYWORDS:
damages, Forest fires, prevention measures, risks, storm winds

When we talk about risks for Mediterranean forests we put forest fires on first place and on second storm winds. On European level damages caused by forest fires make 16% and storm winds 51% of all forest damages (assessment for period 2005-2010) but for Mediterranean part the ratio of damages caused by forest fires is much more higher than one caused by storm winds. This is also the case for Mediterranean part of Croatia which stretches along the Adriatic coast. Forest fires represent most serious and constant danger for forests which destroys the forest and forest land and caused degradation of habitats, worsen the forest soil quality, caused erosion and changes in ecological stability and loss of biodiversity. They can destroy waste areas of forests and by this caused serious and no reversal changes in landscape reduce attractiveness of touristic destinations, also they endanger human lives, houses and infrastructure, causing damages and losses in economy. Storm winds also caused lot of damages in forests and it seems that their impact and importance will only grow over the time under the influence of climate changes. Damages caused by storm winds have serious economic and social consequences and of most importance is to prevent them whenever is possible or to manage those which we can't prevent. As they are part of natural dynamics in forest ecosystems they can seriously influence and change the stand structure and evolutionary processes related to regeneration and succession in forest stands. Smaller damages can even increase dynamic and diversity in small groups of trees which can stimulate regeneration, increase amount of dead wood in forests and influence microclimatic conditions, also it can increase biodiversity and at the same time stay on acceptable economic level of damage. Management of forest fires' risks are in first place connected to forest management measures, starting from guarding, monitoring of forests and education of users in sense of prevention, and in sense to enable fast reaction in forest fires fighting and forest regeneration after forest fires. Risk management related to storm winds are connected to forest management measures, distribution of risks inside the forest complex and acceptance of losses when costs of prevention exceed damages. Paper present methodology for assessment of damages caused by those two main causes and also measures for prevention, risks reduction and regeneration.

NUTRITION AND VITALITY OF FOREST TREES: INTERRELATIONS AND CLIMATIC DEPENDENCIES

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KEYWORDS:
adaptive capacity, crown condition, drought, foliar analysis, vitality indicators

Tree vitality or condition can be defined as the ability of a tree to assimilate, to survive stress and to react to changing conditions. Several factors have been recognized to influence tree vitality, and the reasons for the deterioration of tree condition can be found in specific interactions of stress factors. One common feature of stress impact is the uneconomic use of nutrients, energy and water, leading to alterations in storage patterns in trees, soils and on the ecosystem level. In response to wide public and political concern about the extensive forest damage observed in many parts of Europe in the second part of the 20th century, The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) was established to collect and compile data on the condition of forest ecosystems across the UNECE region and monitor their vitality over time. The assessment of crown condition is central to the ICP Forests operated under the UNECE since 1985, with crown defoliation an essential, but non-specific indicator of tree vitality. Typically the defoliation of trees can change from year to year and will rise sharply under heavy stress (such as drought).

Loss of nutrients from the system, disruption of nutrient cycling and uptake, or imbalances in nutrient status may be associated with declines in tree condition. The lack of a certain element will result in hindering of dependent physiological functions, depending on the severity of the deficiency. For instance, low calcium concentrations in leaves, as a result of lower uptake in dry conditions, can further reduce the effectivity of control mechanisms regulating closing of the stomata. New research evidence shows that phosphorus concentrations in foliage of forest trees in Europe are decreasing at an alarming rate.

Changed climate properties can be critical for the condition of trees, as they can bring about the disturbed water absorption and transport, and water deficits cause inadequate nutrition of trees with a subsequent loss of vitality. Still, the sequence of drought-induced physiological disturbances that lead to the dieback of trees is largely unresolved. Our previous research shows that a) defoliation and nutritional status are both linked to weather conditions (combined influence of precipitation and temperature), b) the interval for the return to defoliation pre-stress values depends as much on the environmental conditions as on the tree species, and c) defoliation and Ca concentration in beech leaves show similar sensitivity to drought, but with different response in time.

PLANT COMMUNITY CHARACTERISTICS AND CERTAIN SOIL PROPERTIES OF BEACH FOREST IN ANDAMAN COASTAL AREA, THAILAND

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KEYWORDS:
Andaman Coastal Area, Beach Forest, Plant Community, Soil, Tsunami

Beach forest is one of the most important forest ecosystems along the coast and seashore. In December 2004, a major tsunami caused by the Indian Ocean earthquake hit the Andaman coastal area of Thailand. After this disaster, there were not only social and economic consequences but also environmental impacts, particularly on the beach and mangrove forests. This research compared the plant community characteristics and certain soil properties of three types of beach forest—casuarina forest (CF), mixed forest (MF), and restored forest after the tsunami (RF) at the Andaman Coastal Research and Development Station, Ranong province, southwestern Thailand. In each forest type, we collected plant and soil data from five plots (each 20 x 20 m) in 2013 or nine years after the tsunami. The analysis of the trees and saplings found that the CF had the highest species richness and highest total basal area (BA) followed by the MF and RF. The MF had the highest Shannon-Wiener index (SWI) for trees and saplings followed by the CF and RF. The RF had the highest tree density followed by the MF and CF but the MF had the highest sapling density followed by the CF and RF. The RF had highest species richness and highest SWI for seedlings followed by the MF and CF, while, the MF had the highest seedling density followed by the RF and CF. The soil classification of these forest types was sand with a pH range of 5.89-7.69 and low nutrient levels. There were significant differences among the forest types for the BA of the trees, species richness, density, and the SWI of saplings and also for soil porosity, pH, phosphorus, potassium, calcium, and magnesium ($p<0.05$). This study concluded that the beach forest dominated by *Casuarina equisetifolia* had different plant community characteristics and soil properties from plant communities dominated by other species such as *Hibiscus tiliaceus* and *Terminalia catappa*. Moreover, after the tsunami, the natural succession by mixed species had not resulted in any changes in the soil properties. This information can be used for beach forest management, reforestation of degraded beach forest, and afforestation after a tsunami.

DIFFERENT ASPECTS OF FOREST DAMAGES IN MINE-POLLUTED DANUBE-DRAVA REGION

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KEYWORDS:
forest damage, mine pollution

We analyzed different aspects of damages in alluvial forests ecosystem of Danube-Drava (Croatia) region, caused by war activities and mine pollution.
25 years after war activities in Croatia, one of the most important ecological issue in Republic of Croatia is mine pollution. In December, 2015., mine suspected area in Croatia spread in 491,57 km^2 which is 1% of land territory. Even 84,5% of this area refer to forests and forest land.
Although war activities in Croatia (1991.-1996.) caused different kind of damages in forests like damages of wood material caused by shrapnel, lower ecosystem services value, lack of silviculturals measures, damages for forestry and forest ecosystems is found to be much greater because of the presence of mines and unexploded ordinance.
Besides direct damages like timber robbery (by enemy) or shrapnel scars on trees (causing also physiological damages), numerous indirect damages are indicated, regarding mine pollution.
Indirect damage to the forest ecosystem and also timber production, continued after the war to the present day: inability to perform silvicultural and protection measures, inability to maintain infrastructure, soil and water mine contamination. Some negative effects such as forest fires or inadequate management and lack of renewing after harvesting due to the mine pollution degraded forests somewhere to the stage of forest clearing. All these claims directly reflect to the forests ecosystem services reducing their value. These claims do not reduce the time lag, but significantly increase.

Degraded forest areas (damaged natural forests, underbrushes, forest clearings) are further endangered by undisturbed spreading of invasive species such as Fraxinus americana and Acer negundo. Forest clearings are also endangered by different herbaceous invasive species such as *Amorpha fruticosa, Asclepias syriaca, Solidago gigantea, Reynoutria japonica, Datura stramonium, Echynocystus lobata* etc.

Beside forest management, mine suspected area also prevents the sustainable management of protected and Natura 2000 areas in Danube-Drava Region. Lack of information about the conservation status of Natura 2000 habitat types and species protected in this Region and its possible shift from favorable state of conservation is main issue. Due to long time of mines and unexploded ordinance pollution, sustainable management of forests ecosystems, as a main mechanism of the Natura 2000 network, is impossible. The current state of forests in this area requires encouragement of human activities in terms of demining and silvicultural activities compatible with the nature conservation objectives for Natura 2000.

NEW EMERGING POLLUTANTS IN THE SOIL

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KEYWORDS:
GC-ECD, PBDEs, Soil contamination, Stocholm Convention

Soil pollution can have lasting socio-economic consequences and the impact on the environment. Pollution can seriously affect the ability of soil to carry out some of its basic functions, it can affect human health by direct contact or by involvement in the food chain. In order to prevent this it is necessary to get more information about contaminated sites and pollutants that are found there. Polybrominated diphenyl ethers (PBDEs) are one of the new emerging pollutants that are found in the environment as a result of using the equipment containing flame retardants such as: electrical equipment, automotive equipment, construction materials, coatings, textiles and polyurethane foam. Four of PBDE congeners: hexa-BDE (hexabromodiphenyl ether) and hepta-BDE (heptabromodiphenyl ether) which are the main components of commercial octa-BDE, and tetra-BDE (tetrabromodiphenyl ether) and penta-BDE (pentabromodiphenyl ether) which are the main components of commercial penta-BDE are on the list of the Stockholm Convention for Persistent Organic Pollutants (POPs). The member states of Convention which have made the list of exceptions have the right to use them for some stated purposes until 2030 but they have certain limitations and prohibitions in the sphere of production, marketing and use of PBDEs.

To obtain more information about the presence of PBDEs in the soil, in this study, first were detected potentially contaminated areas such as: landfills, marshalling yards, dumps of secondary raw materials and automotive wastes. Sampled soil from these locations was analysed by gas chromatographic analysis with electron capture detection. Concentrations of PBDEs ranged from 4.4 to 729 $\mu g \cdot kg^{-1}$ of absolutely dry soil. The most polluted was the sample that has been taken near the plot on which they are stored waste secondary raw materials. The obtained data were analyzed using the Pearson's chi-squared test which showed that the hypothesis of independence of concentrations of PBDE congeners and the percentage of organic carbon, and humus in soil can be rejected in contrast to dependence of concentrations of PBDE congeners and the mechanical properties of soil where the hypothesis of independence can not be rejected.

PHOTOSYNTHETIC ACTIVITY AND VEGETATIVE GROWTH OF EUROPEAN PEDUNCULATE OAK POPULATION IN DROUGHT AND POST-DROUGHT PERIOD

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KEYWORDS:
drought, pedunculate oak, photosynthesis, post-drought, vegetative growth

Forest trees, in its natural environment, are usually exposed to short or long term drought periods. Result can be drought stress that has negative effect on photosynthetic activity and vegetative growth. Nevertheless, in post-drought periods when there is again sufficient water supply, trees have ability to recover its photosynthetic activity and lost vegetative growth. Response of tree species population on drought stress and its ability to recover in post-drought period is considered as acclimation to duration and frequency of drought periods in its habitat.

Response of photosynthetic activity and vegetative growth (i.e. shoot height and stem diameter growth) to long-lasting drought and post-drought period was monitored in saplings of a six European pedunculate oak populations (i.e. Estonia, Lithuania, Poland, Hungary, Croatia, and Italy) in greenhouse experiment with experimentally controlled water supply. Investigated populations originate from sites that differ in precipitation sums during vegetation periods (281.0 – 515.4 mm). Instantaneous rates of net-photosynthesis (μmol CO_2 m^{-2} s^{-1}), **pre-dawn leaf water potentials (MPa)** and weekly measured vegetative growth was assessed in stressed and non-stressed saplings over the course of an entire vegetation season (1st April – 22nd October 2015). The photosynthesis, **leaf water potentials**, and vegetative growth was followed in two phases: during long-lasting drought period (1st April – 21stJuly) and during post-drought period (22nd July – 22nd October).

During drought period strong drought stress was observed in populations (i.e. Poland, Croatia and Italy) from sites with higher precipitation (above 376.8 mm), while low to medium stress was observed in populations (i.e. Estonia, Lithuania and Hungary) from sites with lower precipitation (below 376.8 mm). In accordance, in populations from sites with higher precipitation significant decrease of photosynthetic activity and height growth was observed, while diameter increment decreased uniformly in all populations. During post-drought period all populations in both treatments were outside of stress conditions. But in these period populations from sites with higher precipitation, that suffered strong drought stress during drought period (incliding Hungarian population which did not suffered strong stress during drought period) had better recovery of photosynthetic activity and vegetative growth.

Obtained results indicate that there is specific response of European pedunculate oak populations to long-lasting drought. This may be an important factor to consider when modelling ecosystem European pedunculate oak forest ecosystem productivity.

DYNAMICS, HYDROLOGICAL RELATIONS AND POLLUTION OF PRECIPITATION AND FLOOD WATERS IN FOREST ECOSYSTEM

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KEYWORDS:
forest ecosystem, hydrological cycle, water pollution

Water in forest ecosystem can be present in the forms of precipitation, flood, groundwater and air humidity. Hydrological water cycle takes place via basic hydrological processes such as evapotranspiration, precipitations, infiltration and outflow. Some infrastructural interventions and recent climatic changes in the area of lowland forests have caused changes of flood water and groundwater trends as well as precipitation and evapotranspiration amounts. Water quality is determined by a large number of indicators that can be classified into physical, chemical and biological indicator groups. One of water quality chemical indicators is presence of metals in water. Higher concentrations of metals in natural waters are undesirable as they are polluters of water systems and dangerous for living organisms. Particularly dangerous are cadmium and lead. The objective of this paper is to analyze watercourse levels, groundwater depths, relations between precipitation waters, flood waters, groundwaters and relative air humidity and evapotranspiration. Further objective is to analyze pollution of precipitation and flood waters in lowland forest ecosystems. Research was conducted in the area of Posavina. Precipitation data of Nova Gradiška meteorological station, watercourse levels of Sava River and groundwater depths data from piezometer station were used for analysis of hydrological relations in lowland forest ecosystems. Evapotranspirationwas calculated using Thorntwait method. For water quality analysis, precipitation water was collected at six sampler sites during the spring of 2015. Flood water and lentic water in three microrelief types was collected in three repetitions during the spring of 2015. Water samples were collected in plastic (polypropylene) bottles of 100 ml volume. Trends of river Sava water levels as well as groundwater levels have dropped significantly. Precipitation volume trend in the research area is positive, but not statistically significant, while evapotranspiration amounts have increased significantly. Significant correlation has been determined between particular water forms in hydrological cycle, more precisely, between precipitation waters, flood waters and groundwaters, as well as relative air humidity and evapotranspiration. Pollution of precipitation waters with metals was not found. Flood water was found to be significantly polluted with Al, Fe and Mn in certain microrelief types.

STAND REGENERATION CHARACTERISTICS OF DINARIC BEECH-SILVER FIR FORESTS IN GORSKI KOTAR REGION

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KEYWORDS:
European beech, recruitment, regeneration structure, selection forest management, silver fir

Beech – fir forests cover about 13% of forest land in Croatia, thus being significant forest resource that is managed by uneven-aged selection management system. Continuous and successful regeneration is an essential prerequisite for selection forest management. Therefore updated and sound information on present state of regeneration is important, especially in the context of a climate change and actual structure of beech – fir forests.

Field measurement has been done on 313 plots in the beech- fir forests of Gorski kotar region, Croatia. The assessment of regeneration was based on measurement of trees 0 to 10 cm dbh (species, number of trees, average height) and also estimation of seedlings up to 1,30 m high (regenerated area in 10% classes, share of tree species, origin of stand establishment, regeneration quality). The aim of this paper is to present and analyze current state of regeneration in Dinaric beech- fir forests of Gorski kotar region, with regard to forest ownership (management model), forest communities and habitat characteristics.

Attributes like success of regeneration, structure of seedlings by species and recruitment of young trees were analyzed regarding to present and historical ownership, forest communities and aim of forest management. Results indicate poor incidence of regeneration especially of silver fir (more than 50% percent of field plots with no regeneration). Fir saplings and young trees (>1.3 m height, ≤10 cm dbh) are registered on 9% of plots, average number being only 165 per ha (all species 2044 per ha). Estimated average share of regenerated area is 16,3 % of total forest area, contributed by 5,2 % of conifers and 3,8 % fir. Total 14 tree species were recorded on regenerated areas, clearly dominated by broadleaves, especially beech (over 50 %). Significant differences in regeneration attributes were proven by ANOVA between current and historical ownership categories, forest communities and habitat characteristics. In order to get better insight on structure of regeneration, it is recommended to improve future assessment by establishing special sub-plots for measurement of seedlings by species.

STAND STRUCTURE AND GROWTH OF MIXED EUROPEANLARCH – LIME FOREST CULTURE IN REPUBLIC OF CROATIA

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KEYWORDS:
Culture establishment, productivity and stability enhancement

Background and Purpose: The study presents mixed European larch – lime forest culture. This two species beside good silvicultural features (high wood production, good quality, fast growth, good competitive ability, etc.) have beneficial influence on site characteristics (fast decomposition of litter, beneficial light conditions). Even though these species have been the object of numerous trials, there are no scientific researches related to their mixture.

Materials and methods: Productivity of european larch and lime trees were evaluated on the basis of height and diameter growth and volume production at the age of 44 years. Research on basic structural parameters (DBH, total height, volume) of measured tree mixture was conducted in lowland part of the Republic of Croatia on „Krcevine" locality (Forest administration „Bjelovar", „Veliki Grđevac" forest office). Trial was established in three repetitions (3 x 20 x 20 m = 1 200 m^2). Forest culture was established on the area of 4,57 hectares in 1971. (line planting). Acquired data were statistically analysed with STATISTICA software.

Results: All analysed parameters showed statistically significant difference (ANOVA, $p < 0,05$). The highest values of DBH, total height and volume possess European larch. Also, the highest values of sd for DBH and total tree height are from lime. These results point to larger dispersion of lime trees in the mixture, which means that lime trees are distributed in all canopy layers.

Conclusion: Conducted analysis presents the first growth results of this kind of species mixture in the Republic of Croatia. Significant differences in structural parameters between larch and lime points to better structure during forest conversion. This multi – layered forest culture, in comparison with one – layered monocultures, provides better light conditions and shelter at the time of conversion. Nevertheless, tending throughout the rotation period, which produces good stability and vitality of forest cultures, is crucial for productivity and minimising risks during conversion to climax species stands. Since available land for afforestation in Croatia is significant and these tree species possess good silvicultural characteristics this mixture should be further monitored.

GEOMETRIC MORPHOMETRIC ANALYSIS OF FRUIT SHAPE VARIABILITY IN CONTINENTAL POPULATIONS OF *Ulmus minor* MILL. SENSU LATISSIMO FROM CROATIA

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KEYWORDS:
elliptic Fourier descriptors, fruit shape variability, geometric morphometrics, morphological differentiation, Ulmus minor Mill. sensu latissimo

The European field elm (*Ulmus minor* Mill. *sensu latissimo*) is an important forest tree species, distributed mainly across southern Europe, where it grows as a common member of lowland pedunculate oak forests. Supplementary to the fact that it has been highly valued for its durable and resistant wood, use of its leaves and fruits as a cattle fodder and even for human nutrition has also been documented. Recently, *U. minor* s.l. populations were severely affected by numerous negative impacts that resulted in reduction of species adaptation potential. Flooding mitigation activities, disturbance of moisture regimes and modification of soil properties had profoundly adverse effects on ecological stability of floodplain forest sites. Moreover, devastating consequences of Dutch elm disease pandemics are evident through strikingly small number of the adult trees remaining in the field. Acknowledging that *U. minor* s.l. is generally sexual species with significant vegetative reproduction potential, decrease in the number of fructificating trees enabled change in reproduction system prioritizing from generative to vegetative way of spread. Prevalence of asexual way of reproduction is higher in populations hardly hit by DED phytopathogen, which are, due to higher incidence of disease vectors - elm bark beetles, mostly found in continental rather than in Mediterranean stands. The aim of this study was to reveal fruit outline shape variability in natural populations of *U. minor* s.l. from continental part of Croatia using elliptic Fourier descriptors. Solely simmetrycal shape variability elements of total 1000 fruit outlines were subjected to consecutive shape analyses. Matrix of Fourier coefficients was generated upon 20 harmonics and each outline was defined by 77 elliptic Forier coefficients. We found geometric morphometrics to be exceptionally applicable tool in expressing trends of morphological variation of elm fruit shapes. By applying Principal Component Analysis, three shape variables were obtained from the variance-covariance matrix. Proportional explained variance for the first, the second and the third principal component was 75,3% ; 13,1% and 4,6% respectively. Analysis of variance, performed on PC scores, showed that all trees within populations differed significantly for every principal component inspected. Separation between four populations on the basis of the first principal component was corroborated. Likewise, significant deviation between three population pairs for the second principal component was also established. Nothwithstanding the fact capacity for sexual reproduction in elms due to DED is constantly decreasing, in this research we report high variability of fruit shapes in *U. minor* s.l. natural populations.

FUNGAL DIVERSITY IN *Dryocosmus kuriphilus* INFECTED CHESTNUT TREE CROWNS

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KEYWORDS:
Cryphonectria parasitica, Dryocosmus kuriphilus, fungal diversity, gall wasp, sweet chestnut

Two invasive organism *Dryocosmus kuriphilus* and *Cryphonectria parasitica* are serios threat to chestnut stands, chestnut trees and the quality of the production of fruit. The interaction of the fungus *C. parasitica* and chestnut gall wasp *D. kuriphilus* and the role of other fungi on the necrotic gall wasp in chestnut stands were investigated during the 2012, 2013 and 2014 years. The study was conducted at 7 sites of Croatia: Medvednica, Ozalj, Samobor, Koprivnica, Lovran, Petrinja and Pokupsko where the 30 branches infected with wasp galls were colected randomly per site. On tree selected sites Samobor, Koprivnica and Pokupsko, three tres per site were felled to take the samples for additionall research in 2014 year. Branches were analysed for the presence of chestnut blight and necrotic gall wasp in the trees crown. From necrotic gall wasp the fungi were isolated and determinated using standard phytopathological and molecular methods. 10 gall wasp per site were randomly collected to investigated the presence of the fungi on *D. kuriphilus* larve. Chestnut fruit were collected on the localities: Medvednica, Samobor and Petrinja. Chestnut fruit were exemined for the presence of the fungi. From necrotic gall wasp the fungi *C. parasitica, Gnomoniopsis* sp., *Colletotrichium acutata, Botryosphaera dothidea, Cytospora* sp., *Diaporthe eres, Botrytis cinerea, Trichothecium roseum, Trichoderma viride, Alternaria alternata, Penicillium sp.* and *Fusarium sp.* were isolated. On chestnut fruit were determinated following fungi: *Aspergillus niger, Aspergillus flavus, Gnomoniopsis* sp., *Colletotrichum acutata, Botryosphaeria dothidea, Ciboria batschiana, Alternaria alternata, Diaporte eres, Botrytis cinerea,Trichothecium roseum, Trichoderma viride, Penicillium* sp., *Fusarium* sp. On the remains of dead larvae *D. kuriphilus* the fungi: *Alternaria alternata, Botrytis cinerea, Fusarium sp, Penicillium* spp were detected. The analysis of dry twigs above gall wasp show that thay were without symptoms of fungi infections and the reason of their drying were physiological conditions. On the chestnut tree crowns infected with D. kuriphilus the diversity of fungi and mutual presence of several types of fungi on gall wasp, larvae of wasp gall and chestnut fruit were observed.

BIOLOGY AND FOOD CHOICE OF INVASIVE BOX TREE MOTH (*Cydalima perspectalis*) IN CROATIA

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KEYWORDS:
alien invasive species, biology, damage, food choice test, pheromone traps

Box tree moth (*Cydalima perspectalis*) is alien invasive species that has rapidly spread across Croatia making substantial damage to box tree plants. We are presenting results of biology and food choice tests of box tree moth in Croatia. Sex pheromones baited traps were used for detailed insight into number of generations and food choice tests were performed in laboratory comparing *Buxus sempervirens, Euonymus japonica and Ilex aquifolium* as host plants. Results showed that the moth is able to complete two generations per year, overwintering as young larva on plants. The food test showed that the moth is able to complete its development only on *B. sempervirens*. Severe outbreaks of box tree moth are continuing across Croatia and first insight into parasitoids complex has revealed that native parasitoids have not yet shifted to this novel invasive host. Our research has also confirmed that live plants trade is one of the main pathways of introduction of exotic plant pests which are becoming serious threath to indigenous plants and ecosystems.

IN SEARCH FOR OPTIMAL VIRUS STRAIN FOR BIOLOGICAL CONTROL OF CHESTNUT BLGHT

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KEYWORDS:
biocontrol, chestnut blight, hypovirulence

Cryphonectria parasitica (Murr.) Barr is an introduced phytopathogenic fungus and causal agent of chestnut blight, a devastating disease of chestnut trees. Since its introduction into Europe in the first half of the 20th century it has caused serious damage in the stands of European chestnut (*Castanea sativa* Mill.). After initial disease outbreak chestnut populations started to recover due to the natural biocontrol of *C. parasitica* with cointroduced dsRNA virus *Cryphonectria hypovirus* 1 (CHV1). CHV1 reduces the virulence of *C. parasitica,* a phenomenon called hypovirulence, thus enabling the recovery of chestnuts. Based on the genetic variability of European populations five subtypes of CHV1 have been defined, differing in their virulence towards the fungal host. In several European countries chestnut blight biocontrol by application of selected hypoviulent C. parasitica strains on active cankers is implemented. The success of biocontrol is limited by high diversity of fungal vegetative (vc) types which impedes the spread of the virus through *C. parasitica* populations. Thus the best practice approach in the biocontrol has to take into account specificities of local C. parasitica and CHV1 populations. The aim of the work was to investigate the effect of Croatian virus strains on different Croatian *C. parasitica* isolates in order to find optimal virus candidate for use in biocontrol treatments of chestnut blight in Croatia. Virus isolates were characterised as "strong" or "weak" based on their impact on fungal growth on chestnut stems. Then they were transferred into three fungal isolates of the same vc type by hyphal anastomosis. The effect of the virus on fungal radial growth in vitro and on the activity of fungal stress response enzymes catalase, glutathione S-transferase and superoxide dismutase was measured. The presence of CHV-1 in the *C. parasitica r*esulted in reduced fungal growth in most virus-fungus combinations. The activities of fungal stress enzymes were affected by the presence of CHV-1, but the direction and intensity of the effects depended on virus and fungus isolate and their combination. Therefore, the "strength" of the virus is not solely determined by its subtype but is very strongly affected by both host and pathogen genotypes. This further confirms that possible biocontrol efforts have to take into account local specificities of *C. parasitica* and CHV1 populations.

NEW INSIGHTS ON DOTHISTROMA NEEDLE BLIGHT ON PINE SPECIES IN CROATIA

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KEYWORDS:
Dothistroma, Mycosphaerella, needle blight, pine

Indigenous and allochthonous pine species in Croatia are of a great silvicultural value and provide numerous commercial and non-commercial benefits. As the pioneer tree species with the ability to colonise degraded sites and improve properties and biological activity of soil, Austrian pine (*Pinus nigra* J.F.Arnold) and Aleppo pine (*Pinus halepensis* Mill.) are the most frequently used species for the afforestation of the Mediterranean karst area in Croatia. Their very important and distinctive anti-erosion and hydrological role have also been proven in various studies conducted in the area of Croatian karst and wider. Besides the afore-mentioned benefits, pine species are often seen as the ornamentals in parks, private yards and urban areas in general, where they have several social functions related to aesthetics, health, recreation and tourism.

Pines in Croatia are the preferred hosts to a certain number of parasitic fungi, including the species from the genus *Dothistroma Hulbary* 1941, causative agents of red band needle blight, known also as *Dothistroma needle* blight. The disease has been reported to have great effects and tendency of spreading on pines and other conifers throughout Europe, causing premature needle defoliation, lower timber yield and eventually tree mortality. In Croatia it has been first reported in 1963. on Austrian pine in the vicinity of Slavonski Brod, from where it has spread to other continental areas and was discovered on several other species (*Pinus mugo* Turra, *Pinus ponderosa* Douglas ex C. Lawson, *P. strobus* L. and P. *densiflora* Siebold & Zucc.), but in limited distribution.

Although the disease can be lethal to the Austrian pine seedlings in nurseries and young trees in forest plantations and urban areas, where it can cause severe economical and ecological damage, only several studies have been conducted on these fungi in Croatia up-to-day. Aim of this research was to study the occurrence of *Dothistroma needle* blight on two locations, one maritime (Istria) and one continental (Đurđevački Peski) in two different periods of the year (spring and autumn) in order to gain more insight into the biology and current spread of these pathogens, which will provide valuable information for the future protective measures of pine species in Croatia.

CURRENT STATUS OF ASH DIEBACK DISEASE *Hymenoscyphus fraxineus* IN CROATIA

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KEYWORDS:
ash dieback disease, disease control measures, Fraxinus angustifolia, Fraxinus excelsior, genetic resistance, Hymenoscyphus fraxineus, mitovirus HfMV1, seed orchards

The indigenous ash species in Croatia have an important ecological and economical value especially in their microhabitats where they are irreplaceable. All three species together (*Fraxinus excelsior* L., *Fraxinus angustifolia* Vahl and *Fraxinus ornus* L.) have a total growing stock of almost 21 million m^3. Since the first record in Eastern Poland and Lithuania in the 1990s the ascomycete fungus *Hymenoscyphus fraxineus* (T. Kowalski) Baral, Queloz & Hosoya (basyonim: *Chalara fraxinea*) has gradually spread across the continent, making this invasive pathogen a new primer threat to the sustainability of ash species in Europe. In Croatia the disease was first recorded on common ash (Fraxinus excelsior L.) in 2009 in the mountain area of Gorski kotar. Hymenoscyphus fraxineus in Croatia has been detected and isolated in natural stands from two of three native ash species, common and narrow-leaved ash (*Fraxinus angustifolia* Vahl). There was a significant temporal shift of isolations and confirmation of the disease on different ash species but the disease spread in just a few years from 5,4% to 89,4% of growing stock is remarkable. Attempts of isolation from the third native ash species *Fraxinus ornus* L., have not been successful in natural conditions up to date.

Research conducted on *Fraxinus excelsior* so far revealed that there is significant difference among individuals, populations and families regarding their tolerance to the *Hymenoscyphus fraxineus*. That is why among the limited disease control measures, the most promising potential option would be to take advantage of natural occurring individuals resistance to the fungus. Implementation of feasible conservation measures in order to preserve the ash in its natural environment is of great importance as a part of sustainable forest management policies in Croatia. Because of the species preservation measures two clonal seed orchards of narrow-leaved ash were established for each of two provenance seed regions in Croatia. This allowed us to conduct preliminary pathogenicity tests with the pathogen *Hymenoscyphus fraxineus* on the familiar genotypic material. Fungal isolates were also tested for the presence of the mitovirus HfMV1 and considered as a potential control measure of the disease. Studies on susceptibility of *F. angustifolia* known genotypes to the fungal pathogen *H. fraxineus* is still an underestimated subject and although a lot of work has been done on genetic resistance of the F. excelsior clones to related pathogen, F. angustifolia as a species has a potential to give us astonishing new results.

THE DEVELOPMENT OF *Lymantria dispar* LARVAE ON JUVENILE AND MATURE FOLIAGE OF *Quercus ilex*

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KEYWORDS:
defoliation, gypsy moth, holm oak, host plant, outbreak

Lymantria dispar is one of the most important forest pests in Europe and North America. It is highly polyphagous and feeds on more than 300 plant species, among which oaks (*Quercus* sp.) are most preferred. Until now it was thought that population of *Lymantria dispar* in Croatia is identical in both continental and Mediterranean region, but recent population dynamics research (outbreaks in continental region occur every 10 – 11 years and 4 – 5 years in Mediterranean) and molecular genetic analyses showed that there is a difference between them. Since in the Mediterranean region one of the main host tree species is Quercus ilex we conducted a laboratory experiment to see what is the performance of a Mediterranean population of *Lymantria dispar* on the *Quercus ilex* juvenile and mature foliage. Individual experiment contained 50 larvae on juvenile foliage and 50 larvae on mature foliage. Parallel with the individual experiment, a group experiment with 120 larvae on each rearing group was conducted. Larvae in indvidual experiment were weighed daily and pupae were sexed at the end of the experiment, also mortality of larvae was recorded every day. Gypsy moth larval mortality was low and development time was shorter on juvenile foliage with high pupation success in both indvidual and group rearing experiment as opposed to mature foliage where larval mortality was high and development time was prolonged with low pupation success. Evident differences in development between *Lymantria* dispar larvae on juvenile and mature foliage has shown that mature foliage is not suitable for larvae even in later instars. Several factors could influence the development success of *Lymantria dispar* larvae in *Quercus ilex* stands such as synchronization between budbreak and larval emergence and also nutritive value of *Quercus ilex* foliage and toughness of larval mandibles.

CONVERSION OF SPRUCE MONOCULTURES TO CLIMAX SESSILE OAK STANDS IN THE CENTRAL PART OF THE REPUBLIC OF CROATIA

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KEYWORDS:
height increment, planting stock, seeding, silvicultural guidance, survival

Norway spruce was highlighted as a best tree species for afforestation among all other autochthonous tree species in Croatia already in the twentieth century. It is especially suitable for afforestation of fern and heath areas in the central part of the country. Diverse management, biotic and abiotic influences, especially climatic disturbances (e.g. storms), resulted in significant economic losses and negative environmental consequences in spruce culture management in sessile oak vegetation belt. Since knowledge on conversion of such forest cultures is scarse this research provides basic knowledge of current conversion needs, risks, methods, and site preparation techniques. This is especially important since the need for the establishment of forest cultures will be emphasized in the future. Conversion is an expensive and complex silvicultural measure, which success depends on numerous factors. such as the structure of a forest culture, its stability against abiotic and biotic influences, health condition of every tree in a stand, site ability to accept climax tree species, physical and chemical characteristics of mineral soil, amount and chemical properties of a forest floor, the correct selection of a conversion method, the type and quality of forest reproduction material and a site preparation technique. Trial plots were established on three localities in sessile oak vegetation belt in the central part of the Republic of Croatia in which significant problems in spruce monocultures have been found (Forest Administration offices Zagreb and Karlovac). The aim was to explore silvicultural possibilities in cases when it is impossible for one to withhold the integrity of a forest culture canopy, which are predicted to be more and more frequent due to climatic disturbances not only in cultures, but natural stands as well. If the success of conversion is uncertain due to numerous limiting factors, it is strongly recom-mended for one to establish a new forest culture (a mixed one) with a bigger share of broad-leaved tree species. Research show that the establishment of Norway spruce forest cultures in the vegetation belt of sessile oak should be avoided in the future because of adverse environmental conditions and increasingly pronounced climate changes, which will certainly constrain the success of the establishment of new forest cultures, as well as subsequent conversion. It is concluded that aforementioned risks could be decreased or even completely avoided.

THE IMPACT OF ENVIRONMENTAL DRIVERS ON *Fraxinus angustifolia* BUDBURST DATES

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KEYWORDS:
climate change, insolation, narrow-leaved ash, precipitation, temperature

The narrow-leaved ash (*Fraxinus angustifolia* Vahl) is a fast growing and light demanding forest tree species, which covers central-southern Europe and northwest Africa, up to the Caucasus. It is a hygrophilic and predominantly thermophilic tree species that favours deep, clayed and moist soils exposed to occasional seasonal flooding. The largest complexes of narrow-leaved ash in Croatia are located along the Sava river.

Spring leaf phenology of temperate deciduous forests is sensitive to climate change and have a crucial role in the forest ecosystems, water and carbon balances, and species distribution. In the context of global climate change, it is important to know the composition and structure of genetic variability, particularly in terms of adaptive potential such as growth, survival and leaf phenology. The goal of research was to determine budburst phase (L2) and the impact of some environemntal drivers (temperature, insolation and precipitations) on budburst dates. Phenological characteristics of leaf phenology of narrow-leaved ash were monitored in the clonal seed orchard of Nova Gradiška over four years of research (2012, 2014, 2015 and 2016). Monitoring included 42 clones originating from three populations (Jasenovac, Novska and Stara Gradiška) with four ramets per each clone (in total 168 plants).

The complexity of a environemntal drivers effect on starting physiological activity in forest trees complicated leaf phenology predictions and modeling. Temperature is important driver for many species but there is also another drivers which have a smaller or greater impact on budburst dates. Along with temperature requirements as the most crucial activating factor in the manifestation of leaf phenology, the research confirmed high correlation between cumulative values of precipitation (from December 1st to the beginning of Phase L2) and the beginning of budburst. Slightly less influence on budburst dates have insolation and the lowest influence have temperature values. The regime of precipitation and water availability in the soil definitely should be an important factor that can affect the expression of phenological characteristic in narrow-leaved ash.

TREE RINGS RESPONSES OF NARROW-LEAVED ASH TO CLIMATE AND HYDROLOGICAL FACTORS

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KEYWORDS:
Climate factors, Narrow leaved ash, Precipitation, Response function, Temperature

In this research we are present the first network of 10 tree-ring chronologies of Narrow-leaved ash (*Fraxinus angustifolia*) from the Central Croatia (Midlle Posavina region) was studied in relation to the climatic (precipitations and temperature) and hydrological (water table of the Sava river and local ground water table) factors. The tree growth reaction to climate variability was analyzed by means of response functions using package TreeClim in R over the last 100 yrs. Results of this research show decreasing of tree rings radial growth in the period from 1979 up to 1985, after the main hydro-technical interventions on the Sava river and stronger signal to precipitation over the last 35 years which may be linked with Climate Change and longer drought period.

ECOSYSTEM SERVICES PROVIDED BY ALIEN INVASIVE PLANT SPECIES

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KEYWORDS:
Ailanthus altissima, balance, ecosystem service, invasive species, management

Alien invasive species are considered to be one of the largest threats to biodiversity globally, but have also a number of potential ecosystem services useful to human well-being. A balanced view of the negative impact on ecosystem and an overview on potential services provided by one of the most widespread invasive alien species in Europe and North America, *Ailanthus altissima* (Mill.) Swingle, is given in the present study. We have identified several ecosystem services such as pharmaceutical (human and agricultural use), nutritional (honey), energetic (fuelwood), regulating (erosion, land reclamation), cultural (ornamental) and their provision by *A. altissima*. Here we particularly present preliminary data on A. altissima extracts potential use as herbicide in urban areas and agriculture. On the other hand, alien invasive species can cause degradation of the services and this issue is also discussed. In conclusion, invasive risk management comprises balanced actions in prevention and removal of alien invasive species and possible uses in boosting ecosystem services. It is therefore necessary to explore all pro and contra elements related to particular species, and apply the most effective invasive risk management model based on systematic data.

GENETIC DIFFERENTIATION OF PEDUNCULATE OAK (*Quercus robur* L.) SEED STANDS BASED ON HEIGHT AND SURVIVAL ANALYSIS IN A FIELD TRIAL 'JASTREBARSKI LUGOVI'

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KEYWORDS:
genetic test, intrapopulation diversity, pattern of genetic differentiation, quantitative traits

Previous studies of morphological and physiological traits of pedunculate oak in Croatia have indicated genetic differentiation of populations as well as high level of intrapopulation genetic diversity. However, reported patterns of genetic differentiation vary by different authors. Research of the pattern of genetic differentiation and diversity of oak populations in Croatia was conducted by analysis of height growth and survival in a filed trial established with progeny from 17 seed stands. Analysis of variance for the studied traits revealed significant differences between populations, which confirm their genetic differentiation. Multivariate regression tree analysis (MRT) was used to determine the pattern of genetic differentiation. The populations were grouped in clusters based on climate variables of their habitats of origin and standardized arithmetic means of the studied quantitative traits in the genetic test. Populations were divided into three clusters for height trait based on beginning of frost-free period and the number of frost-free days. Populations originating from habitats where period free of spring frosts begins relatively later had lower mean heights. Populations that were highest on average originate from the habitats where early autumn frosts occur earlier on average. For the survival populations were firstly separated due to Hargreaves's reference evaporation. This variable indicates the potential evapotranspiration of an area, and points to the aridity or humidity of a habitat. Two populations originating from relatively most humid habitats had lowest mean survival. Remaining populations were clustered based on the average temperature in winter. Populations originating from relatively arid and warmer habitats in winter performed highest mean survival. Therefore, climate in the trial during the analyzed period probably was not favorable for the populations originating from moister habitats. MRT analysis indicates ecotypic pattern of the population's genetic differentiation driven by environmental differences in the habitats of origin. This study is part of research projects "Forest tree breeding and seed husbandry" 024-0242108-2099 (Ministry of Science, Education and Sports of the Republic of Croatia) and "Conservation of genetic resources forest trees in the light of climate change" ConForClim 8131 (Croatian Science Foundation).

STUDY OF RARE SPECIES AND FOREST SITES OF HIGH CONSERVATION VALUE IN GEORGIA

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KEYWORDS:
Arbutus andrachne L., Conservation, HCV, Osmanthus decorus Boiss. & Balansa, Seed bank

The forests of Georgia are distinguished by rich biodiversity, abundance of rare habitats and differing ecosystems, where endemic, relict and genetically important species grow. The increasing anthropogenic impact and global climate change afflict damage to the species and habitats, their area is extremely narrowed.

Information about condition of these species was obsolete and based on 25-30 years old data. With the aim of sustainable management of ecosystems it is necessary to study rare species and also forest sites of high conservation value (HCV).

The goal of our research was a study of areas of the relict species of Colchic forests - Greek strawberry tree (*Arbutus andrachne* L.) and osmanthus (*Osmanthus decorus* Boiss. & Balansa), estimation of their diversity, planning of conservation measures, and also - revealing of forest sites of high conservation value by modern standards.

The conducted studies have found out that the area of *Arbutus andrachne* L., spread in Atchara only in one place, is extremely narrowed. The number of specimens is decreased by 15% in comparison with the 30-40 years old data.

The second important species, growing in Colchic forests, is *Osmanthus decorus* Boiss. & Balansa. In Georgia the species is spread only between the Atchara- Imereti ridge and Shavsheti ridge. The species is under heavy anthropogenic impact and its area is gradually narrowed.
With the aim of conservation of the mentioned species seeds are pocessed and kept in the gene bank, live collection is created, where these species grow.

Within our studies we registered the rare habitats and sites of high conservation value of the unique Colchic forests. Two important forest sites have been described: 1) In Qeda municipality, on the Koslitavi mountain, where mixed leaved forest is presented, with dominance of spruce and beech, with wide spectrum of Colchic elements; the especial value is given by *Rhododendron smirnowii* Trautv. in the underwood, which area is also very narrow; it is a genetically important species. 2) On the slope of the mountain adjacent to the village Gorkhanauli in Shuakhevi municipality, where we have a fragment of relict forest of the Miocenic period with participation of the Caucasian pine (*Pinus sosnowskyi* Nakai), Tchorokhi oak (*Quercus dschorochensis* Kotschy) and Greek strawberry tree (*Arbutus andrachne* L); cistus (*Cistus creticus* L.) grows in underwood.

Recommendations are being prepared - to include the mentioned forest areas in the list of Protected areas.

COMPARISON OF ASSESSMENT CROWN DAMAGE USING ANALOG AND DIGITAL COLOR INFRARED (CIR) AERIAL PHOTOGRAPHS

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KEYWORDS:
crown damage assessment, digital and analog CIR aerial photographs, digital photogrammetric workstation, mirror stereoscope

Efforts to mitigate negative consequences of massive forest dieback include the implementation of economic measures, monitoring the health status of individual trees and assessment of crown damage. Apart from terrestrial methods, forest health is also determined with remote sensing methods, which involve interpretation of color infrared (CIR) aerial photographs.

Inventory of forest damage has so far been conducted with photo interpretation of analog aerial photographs on analytical stereo instruments. With the advancement of technology, analog images have been replaced by digital and analytical stereo instruments – by digital photogrammetric workstations, and interpretation is done on the computer screen.
Inventory of forest damage by using aerial photography is based on the establishment of the degree of damage to individual trees (crowns) using a well-designed photointerpretation key. Reliable statistic data of forest damage can be obtained based on interpretation of CIR aerial photographs. The main goal of the research was to compare the results of interpreting analog and digital CIR aerial photographs, as well as define the most reliable interpretation method for the assessment of tree health status for operational use.

Analog and digital aerial photographs of the management units Josip Kozarac and Opeke from two recording periods (1989 and 2008) were interpreted. . At each point of the 100x100 m grid, four nearest trees (crowns) were estimated and damage indicators (damage-O, mean damage-SO, damage index-IO, mean damage1-SO1) were calculated for individual tree species, for all the interpreted species together, per surveying strips, and for the total research area.

Based on calculated damage indicators obtained by interpreting analog and digital recordings from 1989 and 2008, it was found that there was no statistically significant difference between the results in terms of tree health assessment.

The existing methods of health status assessment thus have been improved and new possibilities of applying digital CIR aerial imagery in forestry have been presented.

OCCURRENCE OF EARLY FRUCTIFICATION IN PEDUNCULATE OAK PROVENANCE TRIALS

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KEYWORDS:
acorn, early fructification, male catkin, provenance trials, Quercus robur L.

Pedunculate oak (*Quercus robur* L.) is one of the most valuable forest tree species in Croatia which occupy approximately two million hectars of the country. According to previous researches, pedunculate oak trees raised from seeds usually reach its sexual maturity at age 60-70 years. To our surprise we noticed pedunculate oak trees fructifying at age of just six years in two field trials. The two trials were established in 2008 and 2010, respectively with an aim to study within-species genetic variability. Trials were established according to the randomised complete block design with three replications (blocks). Twenty open-pollinated (OP) progenies originating from 22 provenances (17 Croatian and 5 Austrian) were planted in both trials. Each OP family was represented by five saplings per replication planted in linear plots. Each provenance was represented by 100 samplings per block planted in rectangular plots with 2,5 x 2 m spacing. The aim of this study was to determine amount of early fructification in the trials, between-provenance differences as well as within-provenance variation for the trait.

CONSERVATION OF GENETIC RESOURCES OF FOREST TREES IN LIGHT OF CLIMATE CHANGES

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KEYWORDS:
climate changes, common beech, conservation, genetic resource, pedunculate oak

The preserving of the genetic diversity of the forest ecosystems is the basis for sustainable management and conservation of the natural composition of the forests. Natural forests cover 95% of the total forest area in Croatia and contain different ecological types and a large number of the forest tree species. Accelerated effects of global climate change: rising temperatures, falling rainfalls, and occurrence of the extreme weather, directly affect the genetic biodiversity of the species. The main objective of the project is to make recommendations for the conservation of the genetic biodiversity of the forest trees in Croatia. The research is based on the common oak and the common beech as a model species. The project is financed by the Croatian Science Foundation in the period from 2014 to 2018. The results of the first year of the research (2014-2015) include activities on international provenance trials and selected seed stands of pedunculate oak (Forest administrations: Karlovac, Našice, and Vinkovci) and common beech (Forest Administration Zagreb). Monitoring (survival, height, winter leaf retention, leaf phenology, pathogens and insects) were made on provenance trials and seed stands of both species. The greenhouse experiment was established to study drought stress. The seedlings of common beech were collected from 16 different provenances throughout Croatia. Every provenance was represented with 150 plants, and a total of 2400 plants were collected. Monitoring of seed production of pedunculate oak and common beech was conducted in chosen seed stands. The seed material of pedunculate oak was collected in 48 collecting traps placed in the stands of different ages (middle-aged, elderly and old forests) in Forest administration Vinkovci. The beechnut crops failed in 2015. For this reason, collecting traps will be set next year in chosen beech stands. All planned research activities in the first year were accomplished according to the working plan of the project.

SEED QUALITY AND HEALTH CONDITION OF BEECHNUTS OF EUROPEAN BEECH (*Fagus sylvatica L.*)

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KEYWORDS:
beechnuts, DNA analysis, Fagus sylvatica, health conditions, pathogens, seed quality

Beechnuts, the seeds of European beech, upon their live span, belong to the biological classes of microbiotic seeds. Microbiotic seeds has life span of a few weeks up to 3 years. Beechnuts belong to the intermediate type of seeds according to storage behaviour. Beechnuts are also deep dormant seeds. Freshly collected beechnuts contain 22-30 % of moisture and so during and after harvesting it can not be stored in bags because the seeds are getting moldy. The averrage viability in good seed crop year in Croatia is 72 %, and the averrage share of empty seeds is 15 %. The aim of this study was to determine the quality of beechnuts and types of pathogens that are found in the seeds which was tested in Laboratory for testing seed quality of Croatian Forest Research Institute. Viability was tested by biochemical test - the Tophographical Tetrazolium Test. Pathogens were determinated using macro and micro morphological analysis and DNA molecular identification using ITS region. Viability of seeds was 33%, the share of decayed seeds were 38%, empty seeds were 19% and other nonviability seeds were 10%. The following pathogens were determined on beechnuts: *Alternaria alternata, Arthrobotrys superba, Botrytis cinerea, Fusarium spp., Penicillium spp., Trichothecium roseum, Mucor spp., Graphium sp., Chaetomium sp.* The viability of beechnuts was low. Share of decayed and empty seeds was high and it negatively influenced the quality of beechnuts.

GEOCHEMICAL ASSESSMENT OF THE WATER QUALITY OF SPRINGS ON THE NORTHWEST SLOPES OF THE IVANŠČICA MOUNTAIN

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KEYWORDS:
carbonate aquifer, hydrochemistry, nutrients, stable isotopes, tritium

Groundwater is the dominant source for drinking water in Croatia. The Mt. Ivanščica is located on the north-west part of Croatia. Ivanščica is the highest mountain in this area with the highest peak 1061 m a.s.l. The mountain is built of Carbon-Perm, Triassic, Cretaceous, Miocene and Quaternary sediments. Carbonate rocks, dolomite and limestone, are the main aquifer. The four major springs (Šumi, Beli Zdenci, Bistrica, Žgano Vino) were formed on the fault zone which is the contact between permeable carbonate sediments and impermeable sediments. The water from the springs is tapped for water supply for the town Ivanec and surrounding settlements. The highest mean yield has Bistrica – 60 l/s, Žgano Vino and Šumi follow with 20 l/s as mean yields, and the lowest mean yield has Beli Zdenci - 4 l/s. In order to make geochemical assessment of the spring water quality, spring water samples were taken from three springs. Prior to taking water samples from individual springs, the following parameters were measured ''in situ'' by probes of WTW company: EC, TDS, T, pH and oxygen content. At the Hydrochemical Laboratory of the Institute of Hydrogeology and Engineering Geology – Croatian Geological Survey, the concentrations of the basic anions: chlorides, sulphates and nitrates were measured by ion chromatograph of the LabAlliance company, whereas the concentrations of orthophosphates and ammonium were measured by the spectrophotometer DL/2010 of the HACH company. The concentrations of the basic cations: calcium, manganese, sodium and potassium were measured by the atomic adsorber of the Perkin Elmer company. The content of HCO_3- was determined by titration. The ratios of stable isotopes of δD and $\delta^{18}O$ in sampled water were measured at the Joanneum Research FmbH in Graz, Austria and tritium was measured at Hydrosys, Budapest, Hungary. At the Croatian Institute of Public Health, Division of Environmental Health, Zagreb microbiological parameters were measured. According to major cations and anions of the spring waters, waters belong to the CaMg-HCO_3 hydrochemical type. This is the primary water type which is principally derived from dissolution of carbonate minerals that compose the aquifer. It was observed very low concentrations of nitrate, sulphate, chloride, and concentrations of ammonium and phosphate were below detection limit. The spring waters are not microbiological polluted. The stable isotope ratio and tritium content show the recharge of spring by precipitation. Also, the tritium content indicates the long circulation time which insure degradation of microorganisms and the good groundwater quality.

DETERMINATION OF CARBON AND NITROGEN IN REFERENCE SOIL SAMPLE

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KEYWORDS:
carbon, comparation, elemental analyser, nitrogen, soil

Within the project "Changes of organic carbon and nitrogen storage capacity in soils and their trends in Croatia" funded by the Croatian Nature and Environment Protection Agency (HAOP), research and chemical analyses of soil has been carried out in different Croatian ecosystems. In order to monitor the reliability of methods of laboratory analyses, as well as to ensure operational quality of analytical methods that can be applied in soil analysis, Inter-laboratory comparation on reference sample in laboraratory of Croatian Forest Reserach Institute and Croatian Geological Survey has been organised. In this work, the interlaboratory measurements and repeatabilty and reproducibility were tested between results of determination total nitrogen and carbon in the reference sample on elemental analyser CNS 2000 (Method A) in the laboratory of Croatian Forest Reserach Institute and on the elemental analyser Flash 2000 (Method B) in the labratory of Croatian Geological Survey. Statistical analysis included comparative description of results for determination of total nitrogen and carbon, descriptive statistics for 2 methods, Boxplot analysis, F test, T test, Regression analyses and Control charts for method B. Chemical analysis of soil are reduced for choise of instruments and methods for determination of elements because of specificity and heterogenity of samples. Therefore this kind of testing will confirm applicability of different element analyser for determination of total nitrogen and carbon.

POSITIVE RESPONSES TO RECENT CLIMATE CHANGES IN THE VEGETATION ACTIVITY OF THE COMMON BEECH (*Fagus sylvatica L.*) ECOSYSTEMS IN CROATIA

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KEYWORDS:
Climate change, Common beech (Fagus sylvatica), Environmental limits, NDVI trends

The purpose of this study was to assess the recent trends in vegetation activity (1981-2013) of the beech ecosystems (bioclimatic types) in Croatia across a wide macro-climatic gradient (Mediterranean, Alpine and Continental) to the recent impacts of climate change. In this study we used Normalized Difference Vegetation Index (NDVI) continuously gathered over the past 30 from NOAA's Advanced Very High Resolution Radiometer (AVHRR) in the framework of the Global Inventory Monitoring and Modeling System (GIMMS) project. AVHRR GIMMS NDVI present global coverage 8 km resolution 15-day composite data set, carefully assembled from different AVHRR sensors, that has been used for numerous local to global scale vegetation time series studies during recent years at continental and global scale. We assessed raster pixel-wise trends and vectors of average vegetation NDVI activity for four major beech forest bioclimatic types: Subalpine beech forest, beech-fir forest, montane beech forest and Sub-mediterranean beech forest type. In addition we statistically infer responses of vegetation (NDVI) using climatic predictors and indicators obtained from European Climate Assessment & Dataset (ECA&D) continuous daily gridded datasets for the respective period. In addition we also analyze main typological properties (climatic, orographic, edaphic) of assessed beech forest types. Our results indicate significant trend of the increase in the vegetation activity of the beech forests together with stronger yearly NDVI variations due to the higher fluctuation of extreme events (dry and wet spells). This study also reveals preferential environmental conditions for beech ecosystem types together with limiting conditions in three margins of the beech distribution area: highest altitudinal zone, south-eastern continental Pannonian zone and the Mediterranean. The results show that the common beech can adapt to a very wide range of environmental conditions: annual mean temperatures from 2.1oC to 13.5oC, annual precipitation from 739 mm to 3444 mm, and altitudinal range from 20.3 m up to 1576 m above sea level.

VEGETATION ANALYSIS DURING THE WINTER USING AN INFRARED CAMERA

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KEYWORDS:
GoPro camera, NDVI, QGIS, SAGA GIS, vegetation activity

The poster presents usage of geostatistical tools for analyzing vegetation activity based on NDVI vegetation index. Theoretical basis of NDVI index, method of calculating it and its application are given as well. Used instruments and their specifications, software solutions for processing photographs and processing procedure are also described. At the end the results for every plant are displayed using raster whose pixels carry the information about NDVI index, using tabular representation of average NDVI values of samples for every single photography and graphic representation of variations of NDVI indexes within given period. Advantages and disadvantages of these methods are discussed and the result is a conclusion about possibility of using them for detecting vegetation activity. Moreover, map of observed plants in the area of Botanical Garden in Zagreb is created according to cartographic visualization rules.

THE TRIAL PLANTATION OF SWEET CHESTNUT – GORNJA BAČUGA

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KEYWORDS:
genetical test, grafting, scion, sweet chestnut

In areas where it occupies a larger area sweet chestnut forms a valuable stands and is a lot more than usual wood. In ethnological terms chestnut often determines and shapes the national customs. Around his wood, fruits and flowers, which provide excellent honey, the whole industry is created that brings high profits. In order to maximize profits from the local population, we selected chestnut trees with large fruit. We established genetical test in the area of Forest Administration Sisak to find out whether genetic or environmental factors cause the size and quality of the fruit indigenous chestnut.
The purpose of the project "Experimental plantation of sweet chestnut – Gornja Bačuga" is, if the genetic and molecular-biological test prove that genetical factors cause the size and quality of the fruit indigenous chestnut, protected cultivar, grow it, and give it the name of the area from which it come. In the fall of 2014 sweet chestnuts fruits were collected and planted. In the autumn of 2015 sweet chestnut seedlings were transplanted in bigger containers. During the winter of 2016 scion from selected trees were collected based on two criteria, fruit size and sugar content. In mid-March the same year scions are grafted on rootstock. The success of grafting is excellent, but the tree is largely infested with chestnut gall wasp (*Dryocosmus kuriphilus* Yatsumatsu) so that almost every scion has grown gall. In addition to research local quality varieties in the same area were planted one-year seedlings 3 French cultivars of sweet chestnut: Maraval, Marsol and Bouche de Betizac. The aim is to explore the extent to which the French cultivars adapted to the local environment conditions can offer an additional source of income to local population.

VITALITY ASSESSMENT OF *Quercus robur* TREES: NUTRITIONAL STATUS, VISUAL AND BIOCHEMICAL INDICATORS

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KEYWORDS:
biochemical indicators, nutritional status, oxidative stress, Quercus robur, visual assessment, vitality

Forests are exposed to a myriad of individual and combined stresses with different strength and duration, as well as many simultaneous and consecutive stress factors that have a strong interaction. With regard to global changes include modifications to a series of environmental factors at the same time and changes in the strength of the various stress factors, knowledge of how plants adapt to successive or combined stresses is crucial for understanding the impact of future climate on vegetation. Differnet methods can be used to study stress in plants and to determine the physiological state of trees in the forest ecosystem. The objective of our reserach on *Quercus robur* L. plot in Jastrebarski lugovi was to assess the extent of oxidative stress on the trees where the visually assessed degree of damage , defoliation of the crown, certain physiologically parameters (nutritional status) were determanated and comparaed with visually healthy trees with the aim of determining effects of varying degrees of stress on the forest ecosystem. In order to estimate the extent of oxidative stress, biochemical indicators such as the contents of malondialdehyde (indicator of lipid peroxidation), H_2O_2 (non-radical ROS), and photosynthetic pigments (chlorophyll) were measured in leaves.

RUNOFF AND SEDIMENT TRANSPORT ON MEDITERRANEAN MICRO-SCALE PLOTS WITH DIFFERENT VEGETATION COVER

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KEYWORDS:
bare ground, grass cover, rainfall, runoff, sediment transport, Spanish broom

Abstract
The study presents an analysis of precipitation, runoff and sediment transport on micro-scale plots, on bare ground and on area covered by grass and Spanish broom (*Spartium junceum* L.), in the Suvava catchment (central Dalmatia, south Croatia). The hydrological experimental plots were set parallel to the inclination of 16°, on marl lime stone and shallow and very skeletal soil (calci-mollic cambisol) and are equipped with rain gauge. At the plots the runoff and suspended sediment were monitored after every rainy day. The monthly runoff was highly variable, ranging between 0.10 to 4.40 mm m^{-2} on the plot covered by Spanish broom; between 0.30 to 9.86 mm m^{-2} on the plots with grass cover and between 1.10 to 21.70 mm m^{-2} on the bare ground. The monthly sediment transport also was highly variable. It was ranging between 0.04 to 0.71 kg ha^{-1} on the plots covered by Spanish broom; grass cover between 0.06 to 11.68 kg ha^{-1} and on bare ground between 0.4 to 558.1 kg ha^{-1} . Average annual runoff on bare ground was bigger for 10 times and on the plot covered by grass 4 times than on plot covered by Spanish broom. Annual coefficients of runoff on the investigated types of vegetation cover were small and did not exceed 10% of total annual rainfall. Sediment transport on bare ground plot was bigger 690 times and under grass cover 13 times than on plot covered by Spanish broom on the same inclination. Research results showed that vegetation cover on experimental plots has big impact on the runoff and sediment transport. Runoff and sediment transport are in strong linear dependence on rainfall quantity, duration and intensity.

IMPACT OF CANOPY ON NATURAL REGENERATION IN OLD STANDS OF BLACK PINE (*Pinus nigra Arnold*) IN THE VINODOL VALLEY

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KEYWORDS:
black pine (Pinus nigra Arnold), impact of the stand, land reclamation effect, natural regeneration, sub-Mediterranean forest culture

The research was carried out in the old forest culture of black pine (*Pinus nigra* Arnold) at the age 85 years, which grows in the area of cultural heritage of the highest category of the old Frankopan castle of Drivenik. The stand has been established for calming floods and today has a protective function.

The experiment was set in three experimental areas, in three different degrees of canopy: in the part of the stand with dense canopy (plot 1), in the part of the stand with incomplete canopy (plot 2) and at the edge of the stand (plot 3). The analyses included: the stand structure (density, basal area and wood volume, all according to the tree species and stand levels with the measurement limit of 10 cm DBH), the advance growth structure which included trees with DBH of 3-10 cm and the new growth structure which included trees with DBH of up to 3 cm. Sample heights were measured for all categories of trees.

The results show that the density of the stand, basal area and wood volume decrease with the reduction in the degree of canopy. The examination of the stand structure by levels reveal development of all levels (vertical canopy). A significant impact of the elements of climax forest community of pubescent oak was recorded only on the plot 3, in the level of trees. The most numerous advance growth was recorded on the plot 2, which was to be expected given the light that shines through to the lower levels. More than five species of trees in the forest community of the pubescent oak appeared in the newgrowth. No black pine newgrowth appeared. The most numerous newgrowth on the plot 2 corresponded to the pubescent oak, oriental hornbeam and hop hornbeam. The most numerous newgrowth on the plot 3 was manna ash.

It can be concluded that the land reclamation effect of the forest culture of black pine was successful, since it calmed the torrential flow and achieved a progressive silvidynamic change over 85 years of its life. A transitional forest structure towards a climax forest structure of the forest community of the sub-Mediterranean vegetation zone was created. The research results show that the form of the stand should be substituted by natural regeneration in the near future, using natural and understory appeared in the stand and applying the irregular shelterwood method.

ASSESSMENT OF MINERAL ELEMENT REMOVAL FROM A PEDUNCULATE OAK STAND BY THINNING – A QUICK METHOD

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KEYWORDS:
dry mass, nitrogen, stem-only harvesting, whole-tree harvesting

According to the Kyoto protocol, industrialized countries – parties to the Protocol, are under obligation to reduce emissions of greenhouse gasses. One of the ways to reduce emissions is to replace energy from fossil fuels by renewable sources. Energy from forest biomass is traditionally regarded as carbon neutral energy source, because CO_2 emissions released into the atmosphere in forest bioenergy combustion are captured back to biomass in forest regrowth.

In the traditional, stem-only harvesting (SOH) the logging residues, treetops, branches and foliage, are left on the site. In contrast, the whole-tree harvesting (WTH) practiced for bioenergy purposes implies the removal of these residues from the site (Röser et al., 2008). Their removal inevitably increases the export of nitrogen (N), because these compartments in many cases contain more N than stemwood (Blanco et al., 2005; Mälkönen, 1974; Palviainen and Finér, 2012; Ukonmaanaho et al., 2008). The sustainability of such intensive harvest regimes can thus be challenged, as the depletion of N may result in the degradation of long-term site productivity (Helmisaari et al., 2011; Jacobson et al., 2000; Kellomäki and Seppälä, 1987; Mälkönen, 1974; Olsson et al., 1996).

On the experimental plot set up in Forest Office Županja, management unit Kusare 22a, which was previously measured and trees marked for thinning, three pedunculate oak trees were chosen for sampling, one nearest to mean diameter, and one each from lower and upper diameter class. Trees were dissected into stemwood and branches down to 7 cm diameter, branches 3 to 7 cm, branches under 3 cm, and leaves. Components were weighed on the spot to determine fresh biomass, and samples were brought to the laboratory of CFRI for volume measurement, drying, weighing of dry mass, and chemical analyses.

Based on the results of analyses and measurements, and taking into account the total mass of trees marked for thinning, here we give an assessment of removal of nitrogen and other mineral elements from the stand by thinning, depending on the modality of biomass use.
Given the average annual deposition of nitrogen (12-14 kg/ha according to measurements on the nearby UNECE ICP Forests intensive monitoring plot 108 in Vrbanja, and removal of nitrogen by stem-only harvesting: approx. 50 kg/ha every 10 years, or on average 5 kg/ha annually, or removal of N by WTH: approx.. 68 kg/ha every 10 years, or on average 6,8 kg/ha annually, the difference is 7-9 kg/ha of excess N input annually, regardless of the harvesting method.

ACCUMULATION OF ORGANIC CARBON IN LAKE AND MARINE SEDIMENTS DURING THE HOLOCENE ON THE EASTERN ADRIATIC

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KEYWORDS:
astern Adriatic, lakes, marine lagoons, organic carbon

In this study, organic carbon contents and their distribution in sediment cores during the Holocene (past 11 700 years) for the costal lakes and lagoons of the Eastern Adriatic are presented for 5 lakes (Vransko jezero on Cres Isalnd, Bokanjačko Blato, Vransko jezero near Biograd, Modro jezero, and Bačinska jezera) and 3 coastal lagoons (Lošinjski kanal, Novigradsko more, Karinsko more and Pirovački zaljev. Organic carbon contents range from approx. 0.5% in lakes areas up to 25% in some shallow marine lagoons (Lošinjski kanal). Vransko jezero near Biograd contains in some areas up to several meters of peat deposits. Relationships between sediment properties such as bulk density, grain size and organic carbon accumulation through the Holocene were investigated. Sediment mass accumulation rates (MAR), based on 14C dating on the cores were used to evaluate organic carbon burial rates which show a wide range of values for both freshwater and marine cores. The presented data characterize that the lakes and coastal sediments act as important sink for organic carbon. Also some of the investigated lagoons show that the accumulation of organic matter was higher during the shallower environments at the beginning of the Holocene. The differences in organic carbon deposition can be explained by the the difference in environments, the sizes of catchments and the prevailing climate during the deposition of organic matter.

APPLICATION OF PHYTOREMEDIATION USING *PLANTAGO LANCEOLATA* L. FOR CADMIUM, NICKEL AND ARSENIC IN CONTROLLED CONDITIONS

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KEYWORDS:
Phytoaccumulation, Plantago lanceolata L., cadmium, nickel, arsenic

Phytoremediation is ever more present in the area of environment friendly technologies. This paper presents the results of the application of phytoremediation in controlled conditions using wild facultative phytoaccumulator from natural habitat – *Plantago lanceolata*. A total of 18 samples from three sites were analyzed. All sampling sites are situated in the area of the National Park „Una": the first site on Kalati plateau, the second site in the village of Ćukovi and the third site in the area along the river Una. The AAS method was used to determine the total content (mg/kg) of toxic element in the soil and plant material. Results are presented through the values of phytoaccumulation factor – PF. According to the obtained values of PF factor, *Plantago lanceolata* proved to be a phytoaccumulator of medium capability for cadmium (PF_{Cd} = 0.17 – 0.44) and arsenic (PF_{As} = 0.10 – 0.30), and of low capability for nickel (PF_{Ni} = 0.03 – 0.08).


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