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**DANUBE - A LIFELINE GOVERNED BY MULTIPLE USES,  
PRESSURES AND A MULTITUDE OF ECOSYSTEM SERVICES**

# **Book of Abstracts**

**Editors: Milan Lehotský, Anna Kidová, Miloš Rusnák, Jozef Dudžák**

**DANUBE – A LIFELINE GOVERNED BY MULTIPLE USES, PRESSURES AND A  
MULTITUDE OF ECOSYSTEM SERVICES**

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# **Impact of construction and operation of small HPS on biotic diversity of the Ukrainian section of the Tisa River basin**

**Sergiy Afanasyev, Liudmyla Guleikova, Olena Lietytska, Oksana Manturova, Oleg Golub**

Institute of hydrobiology NAS of Ukraine, 12 Heroiv Stalingrada Ave., 04210, Kyiv, Ukraine

Corresponding author's e-mail: safanasyev@ukr.net

The biotic diversity of mountainous rivers within sections affected by small HPS was studied. Species composition and diversity of plants and animals, as well as migration behaviour of fishes and invertebrates was investigated. Methodic was developed for assessment of the small HPP construction and operation on the small rivers in format of ecological block of ESIA (approved by EBRD) and recommendations on mitigation of the negative impact on biodiversity and fish stock, as well as the fish passes design and assessment of their effectiveness.

**Keywords:** biotic diversity, small HPS, Tisa basin, ecological state and potential.

## ***Pistia stratiotes* L. 1753 – an emerging invader in Serbian rivers?**

**Ana Anđelković<sup>b</sup>, Milica Živković<sup>a</sup>, Maja Novković<sup>a</sup>, Dušanka Cvijanović<sup>a</sup>, Dragana Vukov<sup>a</sup>, Miloš Ilić<sup>a</sup>, Branko Miljanović<sup>a</sup>, Šandor Šipoš<sup>a</sup>, Nemanja Pankov<sup>a</sup>, Danijela Pavlović<sup>b</sup>, Dragana Marisavljević<sup>b</sup>, Snežana Radulović<sup>a</sup>**

<sup>a</sup> Department of Biology and Ecology, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 2, 21 000 Novi Sad

<sup>b</sup> Institute for Plant Protection and Environment, Belgrade, Serbia, Teodora Drajzera 9, 11040 Belgrade, Serbia

Corresponding author's e-mail: milica.zivkovic@dbe.uns.ac.rs,  
dusanka.cvijanovic@dbe.uns.ac.rs

*Pistia stratiotes* L.1753 (water lettuce) is a perennial, free-floating freshwater macrophyte. It is one of the most widely distributed aquatic plants, which is highly invasive and has been known to cause disruptions in the functioning of stagnant and slow-moving waters. Since its introduction into Europe in the 20<sup>th</sup> century, it has been recorded in 11 European countries. Although *P. stratiotes* has been previously documented in the thermal waters of south-eastern and southern Serbia, this finding represents its first record in the running waters of Vojvodina Province.

A regular monitoring survey was conducted in October 2017 along the Begej river in Vojvodina Province (Serbia), during which dense populations of *P. stratiotes* were recorded for the first time near Srpski Itebej, close to the Romanian border. The field trip was repeated in November 2017, when its presence was confirmed. The samples were collected, photographed *in situ* and subsequently deposited in the BUNS Herbarium (accession number: 2-1515). Relevant environmental characteristics were recorded *in situ* and water samples collected for chemical analysis.

Previous records of *P. stratiotes* from the Sićevačka klisura gorge and Rgoška banja spa have been limited to thermally abnormal waters. Therefore, this new finding could be attributed to its spread from Romania, where it has previously been reported. However, although this is the most likely pathway, discarded aquarium plants could also be a possible source of introduction. Regardless of its source, this new record calls for further monitoring to ascertain whether these populations will survive the winter months. Also, as the exact population range and density of *P. stratiotes* are still unknown, it is hard to predict the future environmental consequences of this introduction, but nevertheless, urgent action needs to be taken, in order to prevent its further spread in the running waters of Serbia and the region.

**Key words:** *Pistia stratiotes* L , aquatic plants, invasive plants, Vojvodina, Serbia

## **Discharge measurement as an important part of the monitoring of extreme events in the Danube basin**

**Robert Berny<sup>a</sup>, David Dalkin<sup>b</sup>**

<sup>a</sup> Hydrometrics Ltd., owner & CEO, Na Vodoteci 186, 250 81 Nehvizdy, Czech republic

<sup>b</sup> Teledyne Marine, Regional Sales Manager, TRDI, 14020 Stowe Dr., Poway, CA 92064, USA

Corresponding author's e-mail: [berny@hydrometrics.cz](mailto:berny@hydrometrics.cz), [david.dalkin@teledyne.com](mailto:david.dalkin@teledyne.com)

Climate change is now worldwide considered as a proven fact. Hand-in-hand with climate change, the rainfall-outflow conditions in many European river basins also rapidly change. The Danube river basin is no exception. In this important area, the problems in prediction of extreme meteorological and hydrological phenomena occurrence takes place more and more often. High floods and - in contrast - relative long periods of minimum rainfall and flow in the rivers cause significant economic damage throughout the Danube basin. To make the predictive models more accurate, it is important to monitor the hydrological situation in the Danube river basin. The monitoring especially needs stable and automated monitoring systems that require continuous maintenance and calibration. That means mainly the calibration of monitoring stations that determine current (immediate) flow in a given river cross section that are only based on water level measurement. Mobile ADCP systems, which have gained a great popularity among users, are now being widely utilized for calibration purposes. They are simple to operate, maintenance-free and - compared to conventional discharge measurement methods (current meter, etc ...) - very accurate. Some modern ADCP systems (RiverPro ADCP - Teledyne RD Instruments) allow - in addition to very reliable measurement of immediate discharge even under difficult climatic and drain conditions - to measure also the content of entrained particulate matter in river beds, i.e. suspended sediments.

After initial calibration, the facility estimates and determines the model of river bed development, sediment transport and the particle sedimentation itself. Flood protection of the properties inhabited by people in the Danube river basin requires a number of comprehensive measures. One important aspect is the early warning of the public against extreme phenomena. That is why the precise measurement of the discharge in the Danube river basin is still more and more important.

**Keywords:** Climate, change, hydrological, discharge, ADCP, flood protection

## Ecosystem Service versus Human Use

### Jürg Bloesch

Emeritus Eawag (Limnology), Dübendorf, Switzerland. Current private address: Stauffacherstrasse 159, 8004 Zürich, Switzerland.

Corresponding author's e-mail: juerg.bloesch@emeriti.eawag.ch

According to Costanza et al. (1997, 2017), “*Ecosystem Services (ES) are the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being: that is, the benefits that people derive from functioning ecosystems.*” The definition of ES by MEA 2005/TEEB 2010 (Millennium Ecosystem Assessment/The Economics of Ecosystems and Biodiversity) is officially used in the EU. In general, four categories are distinguished: supporting or habitat services, provisioning services, regulating services, and cultural services. However, this categorization intermixes true ES with human use. For example, while pollination is certainly a true ES, ecotourism obviously is not. I argue that this anthropocentric view including the monetization of ES should be abandoned as humans are part of nature and the global ecosystem GAIA. Thus, it should be clearly differentiated between service and use. The application of human technology, ultimately enabling use and, hence, overexploitation, can be considered as making up the difference, although this boundary is not sharp. In the political environmental debate, threatened ecosystems can be better protected and non-sustainable exploitation of natural goods by humans can be mitigated or even prevented if human use is kept separate from ecosystem services.

**Keywords:** Definition, ecosystem function, ecosystem protection, human pressures, nature exploitation, sustainability.

# Danube Under Pressure – A Personal Analysis

## Jürg Bloesch

Emeritus Eawag (Limnology), Dübendorf, Switzerland. Current private address: Stauffacherstrasse 159, 8004 Zürich, Switzerland.

Corresponding author's e-mail: juerg.bloesch@emeriti.eawag.ch

Drivers, pressures and threats to riverine ecosystems are well known and not specific to the Danube River Basin (DRB). These encompass mainly pollution, hydropower, navigation, flood protection, water abstraction, overexploitation, invasive exotic species, land use, new infrastructure, and global climate change. Basically, human uses or the results thereof interfere with ecosystem services (ES) when considering the technology invented and developed by humans. This often ends in non-sustainable exploitation of ecosystems and natural products. Scaling matters and many local to regional effects of human activities interact to threaten the global ecosystem. At the end, the philosophical dimension about nature and sustainability also must be stressed.

My DRB analysis is based on over 20 years of experience in the IAD. Here, I will elucidate various case studies such as the navigation projects in the Lower Danube, the Iron Gate's hydropower dams, the ICPDR Joint Danube Survey 3 on hydromorphology and designated heavily modified water bodies (HMWB), and the sediment budget of the Danube River.

In the context of national environmental law and implementation of the EU-WFD, some guidelines or principles should be used to mitigate the pressures on aquatic ecosystems: integrative water management, conservation has priority over restoration; best available technique or practice; fight the cause, not the effect, i.e. no end-of-pipe-solutions; polluter (causer) pays; work with, not against nature; cooperation between experts and managers; public participation is more than open access workshops; non-deterioration of the present status; and precaution and solidarity.

Beyond these general managerial recommendations, we should think about the contributions of individuals (bottom-up approach). Personal skills, commitment, courage and patience are prerequisites. Scientists should closely link with environmental NGOs. The role of science is to investigate and understand complex ecosystems, teach about their function at all levels (particularly managers and politicians), and perform quality controls of projects.

**Key words:** Human activity, science, ecosystem function, scaling, conservation, restoration.

## **Role of artificial ponds for maintaining macrophyte diversity**

**Kateřina Bubíková<sup>a</sup>, Richard Hrivnák<sup>b</sup>**

<sup>a</sup> Water Research Institute, Nám. arm. gen. L. Svobodu 5, 81249 Bratislava, Slovakia

<sup>b</sup> Institute of Botany, Plant Science and Biodiversity Centre, Slovak Academy of Sciences, Dúbravská cesta 9, 84523 Bratislava, Slovakia

Corresponding author's e-mail: [katka.bubikova@gmail.com](mailto:katka.bubikova@gmail.com)

Freshwaters belongs to the most threatened biotopes worldwide so current science interest is also targeted on assessment of how artificial waterbodies could serve as suitable secondary habitats for macrophytes. But due to missing information to what extent are man-made waterbodies important for macrophyte diversity we decided to conduct research focused on comparison of macrophyte alpha, beta and gamma diversity between natural and artificial ponds. We investigated macrophyte composition in 69 ponds of both natural and artificial origin in Slovakia. Then, we splitted the data into four subsets according to species categories (helophytes, hydrophytes, red list species and all species; non-aquatic species were excluded), counted diversity metrics and ran proper statistical analyses for comparison between artificial and natural ponds. For local (alpha) diversity, the significant difference was obtained only in the case of helophytes. Among-site (beta) diversity significantly differed for all the species groups. Regional (gamma) diversity of all the groups were higher in natural ponds with the exception of hydrophytes, but significant differences were obtained for helophytes and all species only, hydrophytes and red list species were not different. Thus, we can conclude that even though natural ponds have a significantly higher regional diversity, local diversity is comparable not only for common species but also endangered red-listed macrophytes. Hence artificial ponds could serve as proper secondary habitats for macrophytes.

**Keywords:** comparative diversity; lentic habitats; aquatic plants; species richness

## **Ecological restoration of the Danube Delta wetland fragmented ecosystems. Șontea-Fortuna area case study**

**Eugenia Cioacă, Marian Mierlă, Mihai Doroftei, Mihai Marinov, Alexandru Dorosencu, Vasile Alexe, Gabriel Lupu, Aurel Năstase, Mihaela Tudor, Orhan Ibram**

Danube Delta National Institute for Research and Development /Ecological Restoration and Species Recovery Department /Biodiversity conservation and Sustainable use of natural resources Department, 165 Babadag Street, 820112, Tulcea, Romania.

Corresponding author's e-mail: eugenia.cioaca@ddni.ro, marian.mierla@ddni.ro, mihai.doroftei@ddni.ro, alexandru.dorosencu@ddni.ro, vasile.alex@ddni.ro, gabriel.lupu@ddni.ro, aurel.nastase@ddni.ro, mihaela.tudor@ddni.ro, orhan.ibram@ddni.ro

Within the Danube Delta Biosphere Reserve, under the Danube River sediment transport (averaged to 2,138 kg/sec, corresponding to the water flow averaged to 6,570 m<sup>3</sup>/s, (Bondar 1994)), alluvial sedimentation intensity is high in some upstream zones of the inner hydrographical network. As result of this fluvial process, wetland ecosystems get fragmented by their disconnection from the main channels, especially, in the Danube River low water level condition. This hydrological condition can last 2-3 months /year and some flora and fauna species feeding and reproduction processes are negatively impacted. In order to improve and maintain an optimum water flow regime inside the aquatic ecosystems, ecological restoration is performed. It consists of hydro-technical works of dredging those silted sectors of channels. Thus, fragmented routes of wild species migration are restored and their feeding and breeding conditions are improved. The paper presents the Șontea-Fortuna zone ecological restoration case study, as a specific objective of the RESTORATION-DD project (<http://restoration-dd.ddni.ro>) which was implemented within 2015-2017, in the framework of the RO02 "Biodiversity and Ecosystems Service" Program ([www.eeagrants.org](http://www.eeagrants.org)). As main action, three secondary channels have been subject to dredging works, over a total length of 13.50 km. Their trough morphology has been re-shaped as the bottom elevation from about + 1.00 m asl (in some sectors), post-restoration reached - 1.5 ÷ - 2.00 m asl, according to the designed values. Within the study area (about 7000 ha, covered by channels, fishery brooks, lakes, low hollows, and swamps), the 7 wetland habitat types and 1116 wild flora and fauna species they shelter have been studied and their pre and post-restoration state is to be presented in this paper to emphasize the improvement they got as result of ecological restoration - a prerequisite measure for biodiversity conservation and protection.

**Keywords:** Danube Delta, wetland fragmented ecosystems, ecological restoration.

# Impact of eutrophication and industrial pollution on biodiversity evolution of the lacustrine ecosystems from the Romanian Sector of the Danube

Olivia Cioboiu<sup>a</sup>, Carmen - Mădălina Cismașiu<sup>b</sup>

<sup>a</sup>The Oltenia Museum Craiova, Section of Natural Sciences, Street Popa Șapcă, no. 8, 200416, Craiova, Romania

<sup>b</sup>Institute of Biology Bucharest, Department of Microbiology, Romanian Academy, Street Splaiul Independenței, No. 296, 060031, Bucharest, Romania

Corresponding author's e-mail: oliviacioboiu@gmail.com, carmen.cismasiu@ibiol.ro

The construction of a 1,158 km long dam on the Romanian course of the Danube led to the disappearance of more than 400,000 hectares of lakes, ponds, marshes. The Danube was partially dammed between 817 and 665 km, and is characterized by structural and functional diversity of lacustrine ecosystems. This sector, covering 56,425 ha, is a sample of the former floodplain, which preserves biocoenotic structures specific to wetlands. Eutrophication is one of the fundamental factors affecting the structure and functionality of lacustrine ecosystems. The benthos facies consists of a thick layer of organic silt and vegetal detritus, explaining the clogging tendency of the lakes. The main groups of benthic invertebrates are Oligochaeta (*Pelosclex ferox*, *Stylaria lacustris*), Chironomidae (*Chironomus plumosus*, *Tendipes semireductus*), Plecoptera (*Amphinemura standfussi*, *Perla marginata*), Bivalves (*Anodonta piscinalis*, *Sphaerium lacustre*). Gastropods represent the dominant group of the benthic production with 37 species, among which *Viviparus acerosus*, *Radix balthica*, *Physella (Costatella) acuta*, *Lymnaea stagnalis*, *Planorbarius coneus* are characteristic to the eutrophic lacustrine ecosystems from the area liable to flooding.

Thus, the development of technological processes based on the activity of indigenous microorganisms demonstrated their involvement in the biogeochemical cycles, by chemical-bacterial solubilisation of industrial wastes and bioprecipitation of metal ions from industrial effluents; concentration and removal of heavy metals from industrial waste waters. Acidophilic microorganisms present in industrial tailings and mining effluents, by the mineralization of organic substances, ensure circulation of organic matter, releasing mineral elements used by plants for their nutrition.

The performed analysis showed that, in the lacustrine ecosystems, gastropod populations have a special role among consumers as they represent an important factor in the accumulation of metal ions from waters and sediments. The species of *Viviparus acerosus*, *Radix balthica*, *Lymnaea stagnalis* are bioindicators of the industrially polluted ecosystems from the Romanian Sector of the Danube.

**Keywords:** eutrophication, lacustrine ecosystems, Danube, microorganisms, gastropods.

# **Ecological effects of hydropower dams in Romania as reflected in scientific studies**

**Gabriela Costea<sup>a</sup>, Doru Banaduc<sup>b</sup>, Mauro Carolli<sup>a</sup>, Martin Puscha<sup>a</sup>**

<sup>a</sup> Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), (Dept. 2) Ecosystem Research, Mueggelseedamm 310 12587 Berlin, Germany

<sup>b</sup> Lucian Blaga University of Sibiu

Corresponding author's e-mail: costea@igb-berlin.de

In Romania, more than 500 micro-hydropower plants exist, which are in various stages of approval, construction, or operation. More than 25% of them are located within or near designated protected areas. This spatial coincidence poses a significant threat to conservation goals in regard to the ecological integrity of Romanian rivers. However, this clear conflict of management targets has far has not been reviewed in a synoptical way. Hence, we performed a literature review on scientific articles reporting effects of river damming on aquatic biodiversity in Romanian rivers, mainly referring to fish. Available scientific studies show severe impacts of hydropower dams on the integrity of river ecosystems, as the modification of riverine habitats, modification of the hydrological regime, of water temperature, turbidity, and sediment load, and by interruption of river continuity.

In addition, we analysed if these impacts on the ecological integrity are reflected by available historic and present records collected by field monitoring of fish. That monitoring data were collected upstream (reference sites) and downstream (impacted sites) of more than 50 small hydropower plants and dams. Studied rivers are distributed all over Romania and belong to various river types in terms of fish fauna, however most of them belong to the trout zone. We report the results of this analysis on the impacts of such interruptions of river continuity on fish communities, and draw suggestions for further studies aiming to demonstrate the impacts of hydropower plants on river ecosystems.

**Keywords:** Romania, rivers, hydropower, fish, monitoring

# **Climate warming affects water temperature in the River Danube and tributaries – present and future perspectives**

**Martin T. Dokulil**

University Innsbruck, Research Department for Limnology, Mondsee, Mondseestrasse 9, A-5310 Mondsee, Austria.

Corresponding author's e-mail: martin.dokulil@univie.ac.at

Global warming increasingly impacts rivers and streams worldwide. Decreased precipitation during summer and less snow cover in winter in Austria since 2016 caused reduced run-off, increased evaporation and low ground-water levels. As a result channel flow in rivers decrease to low level. Long-term water temperature data from the River Danube and selected tributaries collected by the Austrian Hydrographic Survey werw analysed. To show trends unequivocal, monthly mean water temperature data are investigated from stations in the Austrian Danube covering the period 1901–2014. These data are related to air temperature, precipitation and discharge. Significant relations of air to water temperature are established at all stations. Time trends are analysed using the non-parametric Kendall test and robust regression. All data are pre-whitened to remove noise. Results indicate a highly significant increase of about 1.4°C, equivalent to 0.01°C per year. The increase in water temperature is related to long distance climate signals. Temperature trends are extrapolated to 2050 using multiple regression analyses and scenarios of future changes in air temperature and discharge.

**Keywords:** climate change, rivers, long-term trend, surface water temperature, prediction.

## **Causes and consequences in recent hydrogeomorphic development of single-thread river in foreland of the High Tatras Mts.**

**Jozef Dudžák, Milan Lehotský, Miloš Rusnák**

Institute of Geography, Slovak Academy of Sciences, Bratislava, Slovakia

Corresponding author's e-mail: geogdudz@savba.sk

The objective of the contribution presents the character and dynamic development of the Poprad River in the river section from Svit to state boundary with Poland with a total length of 87.5 river kilometers. The aim of the study were to identify morphological changes as a river bar area, bank width and lateral bank shift based on remote sensed data (1949, 1986, 2003 and 2014) in the GIS environment. The interpretation of the causes of morphological changes is based on an analysis of variability of four initiators: hydrological input, composition of riparian zone, forestation of catchment and human impact. Human impact has been identified as a dominant factor in changing the behavior of the river for last 65 years due to channelization from 7.8% (1949) to 30.6% (2014). The deforestation as an indirect human impact in the source zone of the river during period 2000-2012 is 10-times larger than in the period 1990-2000. The research was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences; 02/0098/18.

**Keywords:** river bar, bank line, multitemporal analysis, development, Poprad

# DANUBIUS-RI: A new European Research Infrastructure for Advanced Studies on River-Sea Systems

**Jana Friedrich<sup>a</sup>, Adrian Stanica<sup>b</sup>, and DANUBIUS-RI consortium**

<sup>a</sup> Helmholtz-Zentrum Geesthacht - Institute of Coastal Research, Biogeochemistry in Coastal Seas, D-21502 Geesthacht, Germany

<sup>b</sup> Romanian National Institute of Marine Geology and Geoecology - GeoEcoMar, Str. Dimitrie Onciul 23-25, 024053 Bucharest, Romania

Corresponding author's e-mail: danubius@hzg.de, danubius.research@geoecomar.ro

The increasing demand to jointly enable intensive human use and environmental protection in river-sea systems requires holistic and integrative research approaches with the ultimate goal of enhanced system understanding. It is becoming widely recognised that there is a need to study River-Sea-Systems as an entire continuum, to provide scientifically underpinned information to enable better-informed and holistically engaged environmental protection of River-Sea systems and support environmental policy making (e.g., WFD, MSFD, UN's 2030 SDG's), to maintain River-Sea System functioning and thus their capacity to provide ecosystem services.

The goal of the "International Centre for Advanced Studies on River-Sea Systems" (DANUBIUS-RI, <http://www.danubius-ri.eu/>) is to enable and support research addressing the conflicts between society's demands, environmental change and environmental protection for river-sea systems worldwide. DANUBIUS-RI will focus on Water Security, Sediment Regime, and Ecosystem Structure and Functioning (including biodiversity), taking into account Climate Change and Extreme Events. More details on the research needs and scientific questions will be presented. DANUBIUS-RI will conjoin research on freshwaters and the interface to marine waters, drawing on existing research excellence across Europe. DANUBIUS-RI will facilitate interdisciplinary research on river-sea systems by providing infrastructure, provide access to a range of European River-Sea systems and will foster the knowledge exchange as well as the access to harmonized data, education and training. DANUBIUS-RI does not intend to become a monitoring infrastructure.

DANUBIUS-RI is on the Roadmap of the European Strategic Forum for Research Infrastructures (ESFRI) since 2016. It is currently being implemented as a distributed research infrastructure in 16 countries in Europe, under the lead of Romania. DANUBIUS-RI shall become operational by 2023. The envisaged lifetime is at least 30 years.

The Research Infrastructure will comprise a Hub and Data Centre, a Technology Transfer Office, as well as Supersites and Nodes across Europe. Nodes will cover Observation, Analysis, Modelling and Socio-economic impact. They will provide facilities and services, data-storage and -provision, experimental and *in-situ* facilities. Supersites will be complementary natural test sites for observation, research and modelling utilizing standardized and experimental methods to study River-Sea systems. The Danube and Danube-Delta – Black Sea System is one of 8 supersites.

**Keywords:** DANUBIUS-RI, ESFRI research infrastructure, river-sea systems, scientific programme,

## **Balancing multiple targets in large river-floodplain systems – biodiversity and ecosystem services in the corridor of the Danube River.**

**Andrea Funk<sup>a,b</sup>, Javier Martínez-López<sup>c</sup>, Florian Pletterbauer<sup>a</sup>, Daniel Trauner<sup>a,b</sup>, Kenneth J. Bagstad<sup>d</sup>, Stefano Balbi<sup>c</sup>, Ainhoa Magrach<sup>c</sup>, Ferdinando Villa<sup>c</sup>, Thomas Hein<sup>a,b</sup>**

<sup>a</sup> University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management, Max Emanuelstr. 17, 1180 Vienna, Austria.

<sup>b</sup> WasserCluster Lunz - Biologische Station Gmb, Dr. Carl Kupelwieser Promenade 5, 3293 Lunz am See, Austria

<sup>c</sup> BC3-Basque Centre for Climate Change, Sede Building 1, 1st floor, Scientific Campus of the University of the Basque Country, 48940, Leioa, Spain.

<sup>d</sup> U.S. Geological Survey, Geosciences & Environmental Change Science Center, PO Box 25046, MS 980, Denver, CO, USA 80225.

Corresponding author's e-mail: [andrea.funk@boku.ac.at](mailto:andrea.funk@boku.ac.at)

Large river-floodplain systems are hotspots of biodiversity and ecosystem services but also used for multiple human activities and are therefore, also hotspots for conflicting interests. The relevance of large rivers and their floodplains for biodiversity and nature conservation is reflected by a high density of Natura 2000 sites as well as designated National Parks, Biosphere Reserves and Nature Parks along fluvial landscapes. In turn, navigation, hydropower generation and flood protection measures are examples of important human activities within large-river floodplain systems that significantly alter the hydro-morphological conditions of the river and adjacent floodplains, making them major threats for biodiversity, ecosystem functions and services. Environmental problems on the Danube are particularly acute and require large-scale, data-driven ecosystem-based management. We take a quantitative approach to assessing biodiversity and ecosystem services focused on the navigable main stem of the Danube River and its floodplains. Relationships between biodiversity and hydro-morphological alteration of the river-floodplain system are analyzed using a Bayesian network approach. We use open-access data to inform this Bayesian network for the navigable stretch of the river Danube, including 1) a hydro-morphological assessment, 2) Copernicus land cover/land use (LCLU) data, 3) waterway status data for inland navigation, 4) hydropower plant location and impact data, and 5) conservation status of widely distributed protected species, including fish and amphibians, collected for EU Habitats and Birds directives. Ecosystem services, including potential for recreation and flood retention, are quantified using the ARIES modeling platform. Finally, we spatially evaluate potential conflicts and synergies of those multiple human activities, biodiversity conservation, restoration, and ecosystem service potential. Our analysis can thus serve as a basis for more strategic, large-scale ecosystem-based management.

**Keywords:** hydro-morphological alteration, Natura 2000, ecosystem based management, Bayesian network.

# The application of the River Ecosystem Service Index to a stretch along the upper Bavarian Danube

Marion Gelhaus<sup>a</sup>, Barbara Stammel<sup>a</sup>, Lars Gerstner<sup>b</sup>, Simone Beichler<sup>c</sup>, Martin Pusch<sup>c</sup> & Bernd Cyffka<sup>a</sup>

<sup>a</sup> Katholische Universität Eichstätt-Ingolstadt, Angewandte Physische Geographie, Aueninstitut Neuburg, Schloss Grünau, 86633 Neuburg a.d. Donau

<sup>b</sup> KIT - Karlsruher Institut für Technologie (KIT), Institut für Geographie und Geoökologie, Abteilung WWF-Auen-Institut, Josefstr.1, 76437 Rastatt

<sup>c</sup> Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB), Müggelseedamm 30, 12587 Berlin,

Corresponding author's e-mail: marion.gelhaus@ku.de, barbara.stammel@ku.de, bernd.cyffka@ku.de, lars.gerstner@kit.edu@kit.edu, beichler@igb-berlin.de, pusch@igb-berlin.de

Floodplain ecosystems offer many benefits to human society and are therefore 'hot spots' of ecosystem services (ES), like flow regulation or provision of drinking water. At the same time, they are subjected to many present and future anthropogenic influences such as intensive agriculture, hydropower or technical flood protection. At the moment, river and floodplain management are acting separately. The new approach of the BMBF-Project 'River Ecosystem Service Index' (RESI) aims to bring together all demands of society on the rivers and floodplains. By applying RESI, changes of ES due to changing management can be determined, evaluated and visualized.

A first practical test of the newly developed RESI was carried out in the model region 'Upper Bavarian Danube' (approx. 80 km) calculating 15 ES. Here, the Danube is strongly regulated by flood protection levees and ten hydropower plants. The floodplain is intensively used (agriculture, gravel mining). To improve flood protection, the water management authority is considering three controlled and up to six uncontrolled retention areas. For the same region, ecological improvements such as ecological flooding, re-connection of channels and river bank restorations are planned as part of a nature conservation project.

To evaluate the different plans equally and to find the best management option for society, four different scenarios were developed and assessed by RESI: 1. flood protection, 2. nature conservation, 3. combination of both and 4. changed land use (without arable land). For the status quo, both ES- 'hot spots' (very high sum of ES provision) and ES- 'cold spots' (very low sum of ES provision) could be identified. Comparing the scenarios with the status quo, changes in the supply of ES could be determined. Trade-offs and synergies between ES were identified. So, recommendations on deficits in ES, sensitive areas and effects of measures can enhance the planning process.

**Keywords:** scenarios, assessment, floodplain, management.

## **Integrating protected area management and ichthyofauna status for Adunații de Geormane Lake (Romania)**

**Ionelia Claudia Goga<sup>a</sup>, Oana Mititelu-Ionuș<sup>b</sup>**

<sup>a</sup>The Oltenia Museum Craiova, Section of Natural Sciences, Street Popa Șapcă No. 8, 200416, Craiova, Romania

<sup>b</sup>University of Craiova, Geography Department, Street A. I. Cuza No. 13, 200585, Craiova, Romania

Corresponding author's e-mail: ioneliagoga@yahoo.com, oana\_ionus@yahoo.com

The purpose of the research is to address current environmental challenges based on close collaboration between stakeholders in order to achieve the sustainable management of Adunații de Geormane Lake. The study issue began in 1972, when the lake was populated with *Ctenopharyngodon idella*, in order to capitalize the abundant macrophyte vegetation; this phenomenon led to the excessive multiplication of the species and extension of the phytoplankton that generated "algal blooms". As a result, the ichthyofaunistic ratio changed and the supremacy of *Ctenopharyngodon idella*, species was taken by *Carassius gibelio*, a species resistant to the lack of oxygen in the water.

In 2000, based on the presence of certain fish species, such as *Misgurnus fossilis*, *Umbra krameri*, *Gobio kessleri*, *Leucaspis delineatus*, *Rhodeus amarus*, the study area was declared a protected area. The results of the field research revealed the presence of 16 species, *Carassius gibelio*, *Ctenopharyngodon idella*, and *Abramis brama* being dominant species.

Beside the ichthyofaunistic study, the importance of the research consists in the proposed measures for the sustainable management by reducing the activities with negative impact (uncontrolled expansion of the human habitat, recreational fishing, recreational activities, non-native invasive species and diffuse pollution) and even tourism promotion of the area.

**Keywords:** ichthyofauna, environmental challenges, Adunații de Geormane.

# Long-term changes in the fish fauna of the Szigetköz region of the Danube, in Hungary

**Gábor Guti**

Centre for ecological research, Hungarian Academy of Sciences, Hungary

Corresponding author's e-mail: sturgeon2020@gmail.com

The Szigetköz is the right side of the extensive alluvial cone stretching from Rajka to Gönyü (r. km 1850-1794) at the Hungarian-Slovak section of the Danube. Its fluvial system possesses a high natural value concerning its habitat structure and biodiversity. With regard to the natural conditions, the biodiversity of characteristic river-floodplain associations was considerable, due to the high habitat diversity resulting from the fluvial dynamics, the frequent flood-controlled resetting towards early successional stages, and the large lateral extension of the floodplains. Significant changes have occurred in the region due to river engineering since the end of the 19th century, and the floodplain has been affected by the operation of the Gabčíkovo hydroelectric power plant since 1992.

The description of long-term changes in the fish fauna was completed by way of evaluation historical data of fishery, assessment of catch statistics, literary review, and ichthyological surveys conducted in the last decades. Suitable publications and reports are available from the 18th century. The native fish fauna includes 54 species, while the alien fish fauna contains 23 species, 11 of which are exotic in Europe. Two species, *Huso huso* and *Acipenser stellatus* are practically extinct from the region. The historical changes of the fish fauna were evaluated in conjunction with human impacts.

**Keywords:** historical fishery, sturgeon, invasive alien species,

# **Sturgeons of the Austro-Hungarian Danube and sturgeon exploitation from the Middle Ages to the early 20<sup>th</sup> century**

**Gertrud Haidvogl**

Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences, Vienna, Gregor-Mendelstrasse 33, 1180 Vienna, Austria.

Corresponding author's e-mail: [gertrud.haidvogl@boku.ac.at](mailto:gertrud.haidvogl@boku.ac.at)

The Austro-Hungarian Danube hosted five native sturgeon species. The value of their meat and other products made fishing one of the earliest impacts on stocks. Little is known about the long-term change of populations as we lack sufficient evidence. Most of the historical sources and remains stem from fishing, trading and consumption, adding various cultural filters on ecological conditions.

Sturgeon fishery in the Austro-Hungarian Danube dates back millennia. Archaeological remains have been found for prehistoric and Roman times. Sources from the 11<sup>th</sup> century and thereafter, document a vivid sturgeon fishery in Austria. In the Early Modern Period, interactions between the specific life cycle of sturgeons and fisheries initiated environmental and societal changes. When in the 16<sup>th</sup> century sturgeon fishermen changed their management in the Hungarian river stretch fish exploitation increased there. Although there is no direct evidence from contemporaneous fishery sources it can be assumed from fishing laws and local by-laws that the numbers of individuals migrating upstream declined. Subsequently, fishery in the Austrian Danube but also fish trading and fish supply changed. Late 18<sup>th</sup> century sources from the Viennese fish-trader guild prove that large quantities of sturgeons were delivered from the Hungarian Danube. A century later, also this supply region had gone due to overfishing and other human modifications of the river.

This contribution presents the interactions between Danube sturgeons as highly targeted fish species, human resources exploitation, fish trading and fish supply from the Middle Ages to the beginning of the 20<sup>th</sup> century. A spatial focus will be on the Viennese Danube and Vienna as major place of sturgeon consumption. The presentation will also critically reflect the potential and limitations of archaeological remains and written sources to reconstruct historical changes of sturgeon stocks and suggests ways forward to better understand the long-term evolution of sturgeon populations.

## **Human River Systems in the 21st century (HR21) – a new interdisciplinary Doctoral School addressing riverine landscapes as dynamic socio-ecological systems**

**Thomas Hein, Thomas Ertl, Wolfram Graf, Helmut Habersack, Gertrud Haidvogel, Christoph Hauer, Gregor Laaha, Guenter Langergraber, Susanne Muhar, Erwin Schmid, Martin Schmid, Stefan Schmutz, Karsten Schulz, Gernot Stoeglehner, Gabriele Weigelhofer, Verena Winiwarter, Sophie Zechmeister-Boltenstern, Marija Zunabovic-Pichler**

University of Natural Resources and Life Sciences, Vienna

Corresponding author's e-mail: [thomas.hein@boku.ac.at](mailto:thomas.hein@boku.ac.at)

Riverine landscapes are complex systems, which provide a multitude of ecosystem services. Multiple pressures, driven by societal processes, far-ranging engineering approaches, changes in environmental conditions, and an intense use of partly conflicting ecosystem services, have modified most of these systems worldwide to industrialized riverine landscapes (IRL) shaped by human – environmental interactions. The close, but complex interaction between environmental and societal processes and the co-evolution of these two spheres urgently require a socio-ecological systems approach in both science and management.

To address this challenge and develop a critical mass in integrated multidisciplinary river science, 18 leading scientists including 3 associated members from four departments of the University of Natural Resources and Life Sciences, Vienna (BOKU) join their disciplinary high-level expertise in the innovative international doctoral school Human-River 21 (HR21). The main aims of HR21 are to address critical knowledge gaps in industrialized riverine landscapes (IRL) and coupled socio-ecological systems research, developing new analytical and modelling tools, train a new generation of scientists in a multi- and transdisciplinary environment and strengthen interdisciplinary Human-River-System research in Vienna and beyond. HR21 targets to provide a new multidisciplinary understanding of the future development of IRL and their effective and sustainable management.

**Keywords:** biodiversity, ecosystem services, resilience, engineering, natural sciences, social sciences

# Changing Rivers - challenges for the management of ecosystem services and biodiversity in the Danube River

Thomas Hein<sup>a,b</sup>, Wolfram Graf<sup>a</sup>, Andrea Funk<sup>a,b</sup>, Gertrud Haidvogel<sup>a</sup>, Florian Pletterbauer<sup>a</sup>, Rafaela Schinegger<sup>a</sup>, Astrid Schmidt-Kloiber<sup>a</sup>, Daniel Trauner<sup>a</sup>, Gabriele Weigelhofer<sup>a,b</sup>

<sup>a</sup> University of Natural Resources and Life Sciences, Vienna, Institute of Hydrobiology and Aquatic Ecosystem Management

<sup>b</sup> WasserCluster Lunz

Corresponding author's e-mail: thomas.hein@boku.ac.at

Rivers are key ecosystems providing a multitude of ecosystem services that are vital for human societies. Moreover, rivers have a high strategic importance for global ecological functions and biodiversity. The Danube River and its basin – as many other large river systems in the world – have experienced severe ecosystem changes and alterations due to multiple human-induced pressures, highly threatening the system's ecological integrity. These threats also impair the provision of a variety of ecosystem services that build the basis for human wellbeing in the entire Danube region. In turn, the mitigation of human-induced pressures is a key issue for river basin management, aiming to improve the ecological status and integrity, and to guarantee the provision of ecosystem services. With regard to the Danube River Basin Management Plan, several significant water management issues have been identified related to different aspects of pollution and hydromorphological alterations. In this paper, we extend the view for future management aspects starting from alterations in river morphology through hydrology and their legacy effects to long-term environmental and societal changes and their combined effects on biodiversity as well as on the provisioning of ecosystem services. Specific examples address how the spreading of neozoa links complex responses of aquatic biota to pressures due to river engineering with potential impacts on aquatic biodiversity. In this context, we target key aspects for future biodiversity management by analyzing the main human activities and pressures that are related to the decline of aquatic biodiversity. In these context spatial patterns of protected areas showing a high biodiversity as well as potential synergies and potential barriers of current environmental policy frameworks will be investigated.

**Keywords:** biodiversity, ecosystem services, invasive alien species, hydrological alterations

## **Beluga and Stellate Sturgeon migration and presence in the Iron Gate II dam area**

**Ștefan Hont<sup>a</sup>, Cristi Trifanov, Marian Mierlă, Marian Paraschiv<sup>a</sup>, Marian Ion Iani<sup>a</sup>, Tihomir Stefanov<sup>b</sup>, Mirjana Lenhardt<sup>c</sup>, Radu Suciua<sup>a</sup>**

<sup>a</sup> Danube Delta National Institute for Research and Development, str. Babadag 165, Tulcea 820112, Romania, Fax: (+4) 0240533547, web: www.ddni.ro

<sup>b</sup> National Museum of Natural History, Tsar Osvoboditel Blvd. 1, 1000 Sofia, Bulgaria

<sup>c</sup> Institute for Biological Research, Despota Stefana 142, 11000 Belgrade, Serbia

Corresponding author's e-mail: stefan.hont@ddni.ro

The anadromous sturgeon species Beluga (*Huso huso*), Russian (*Acipenser gueldenstaedti*) and Stellate Sturgeon (*A. stellatus*) use to spawn further upstream in the spawning sites located in Middle Danube River. Therefore the damming of Danube River at Iron Gates I (Danube Km 943) in 1974 and Iron Gates II (D. Km 863) in 1984 have obstructed the sturgeon migration and had significant impact over natural reproduction of these species. In 1986 following the completion of the Iron Gates II dam, the presence of sturgeon cluster downstream of the barrage was reported. Since then, no other scientific studies have been carried out to identify the presence or absence of sturgeons downstream the dam until 2013 when using acoustic telemetry equipment it was possible to record again sturgeons in the dam area. Tagged adult Beluga and Stellate Sturgeon were recorded between river kilometre (rkm) 847 and the Hydropower complex, or in the close vicinity of the dam. For a better understanding of the behaviour and the preferred sturgeon locations near the dam, bathymetric profiles were made with the depths and the profiles of the river downstream the Iron Gate II dam. Collecting data about the presence of sturgeons and their behaviour in the dam area will help identify the best options for building in the future fish passage for sturgeons and other migratory fish species.

**Keywords:** Migration, behaviour, sturgeon, telemetry, Iron Gate II dam.

## Long-term cladoceran and copepod assemblages monitoring in the Danube floodplain area (Slovak-Hungarian stretch)

**Marta Illyová**

Plant Science and Biodiversity Centre, Slovak Academy of Sciences, Dúbravská cesta 9, SK-845 23 Bratislava, Slovakia

Corresponding author's e-mail: illyovamarta@gmail.com

In 1992 the Gabčíkovo hydroelectric power plant was put into operation. Since seven sites: two main river channel/old river bed, two side arm of a parapotamal type and three side arm of plesiopotamal type, that were selected because they represent a basic type of local aquatic environment, have been monitored. Already after the first years of operation, the structure of cladoceran and copepod assemblages in the by-passed section and in the adjacent floodplain water bodies has changed. Euplanktonic species prevailed on all sampling sites before damming. In periods after damming, littoral species, and later also a euplanktonic forms, dominated on the main channel sampling sites. Great changes have been observed in the previous parapotamal side arm, artificially fed with water from the head-race canal. The dominance the tychoplanktonic species has increased, while the typical euplanktonic species have disappeared. In plesiopotamal side arms with rich littoral macrovegetation during periods after damming, phytophilous cladoceran species were the ones with the highest occurrence. Based on more than twenty years data, the cladoceran and copepod habitat preferences, using habitat values, were quantified. Of 71 recorded cladoceran species, 19 taxa showed a preference for old river bed, 24 species preferred eupotamal B/parapotamal waters, and 28 cladocerans were found to prefer the plesiopotamal habitat type. Four species, *Bosmina longispina*, *Ilyocryptus acutifrons*, *Ilyocryptus cuneatus*, and *Moina weismanni*, were recorded exclusively in the main channel. Out of 50 recorded copepods species, 11 species manifest a preference for eupotamal habitats, 18 taxa preferred eupotamal B/parapotamal habitats and 21 species were found to prefer the plesiopotamal habitat type. Five species, two cyclopoids *Diacyclops languidoides*, *D. crassicaudis*, and three harpacticoids *Bryocamptus (B.) mrazeki*, *Bryocamptus (Rh.) zschokkei* and *Echinocamptus pilosus* were recorded exclusively in the main channel. The study was supported by the project VEGA 1/119/16 and VEGA 2/0030/17.

**Keywords:** biological assessment, floodplains, Copepoda, Cladocera, Danube River.

## Assessment Of Genotoxic Potential Of The Velika Morava River Basin

Jovanović<sup>a</sup>, J., Kolarević<sup>a</sup>, S., Milošković<sup>b</sup>, A., Radojković<sup>b</sup>, N., Simić<sup>b</sup>, V., Dojčinović<sup>c</sup>, B., Kračun-Kolarević<sup>d</sup>, M., Paunović<sup>d</sup>, M., Kostić<sup>e</sup>, J., Sunjog<sup>e</sup>, K., Vuković-Gačić<sup>a</sup>, B.

<sup>a</sup> University of Belgrade, Faculty of Biology, Chair of Microbiology, Center for Genotoxicology and Ecogenotoxicology, Studentski trg 16, 11000 Belgrade, Serbia

<sup>b</sup> University of Kragujevac, Faculty of Science, Institute of Biology and Ecology, Radoja Domanovića 12, 34000 Kragujevac, Serbia

<sup>c</sup> University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, 11000 Belgrade, Serbia

<sup>d</sup> University of Belgrade, Institute for Biological Research "Siniša Stanković", Despota Stefana 142, 11000 Belgrade, Serbia

<sup>e</sup> University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11000 Belgrade, Serbia

Corresponding author's e-mail: b3010\_2016@stud.bio.bg.ac.rs

The Danube River is highly affected by human activity. Wastewaters discharging into the Danube River stream are one of the major problems, especially at Croatia-Serbia river section. The Velika Morava River is the greatest Serbian river and a significant tributary of the Danube River. Consequently, the water quality of the Velika Morava River could have a great impact on the water quality of the Danube River.

In this study, the level of genotoxic potential along the Velika Morava River Basin was evaluated by using a battery of *in vitro* and *in situ* bioassays. Within the *in vitro* approach, SOS/*umuC* test on *Salmonella thyphimurium* TA1535/pSK1002 and the comet assay on HepG2 cell line were employed for genotoxicity testing of native water samples. The level of DNA damage on erythrocytes of bleak specimens (*Alburnus alburnus*) was observed using the alkaline and Fpg modified comet and micronucleus assays within *in situ* testing. The concentration of toxic metals in fish tissues and physico-chemical water status were chosen as parameters of pollution pressure on selected sites.

Obtained results indicated lower sensitivity of selected *in vitro* tests when compared to *in situ*. Also, the tests using the *in situ* approach showed a range of sensitivity. Namely, the alkaline comet assay showed a greater potential than Fpg modified comet test and micronucleus assay in distinguishing between sites. According to results, application of complex bioassays battery was shown as a better choice in eco/genotoxicological studies than using only one bioassay. In that way, a holistic approach is appropriate for this type of study.

**Keywords:** genotoxic potential, *in vitro* bioassays, *in situ* bioassays, holistic approach, water pollution.

## Seasonal dynamic of chlorophyll-a concentration in two small floodplain lakes at Lower Danube based on Sentinel 2 data.

Stefan Kazakov<sup>a</sup>, Vulko Biserkov<sup>a</sup>, Luchezar Pehlivanov<sup>a</sup>, Stoyan Nedkov<sup>b</sup>

<sup>a</sup> Insititute of Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences, Gagarin 2, 1113, Sofia, Bulgaria.

<sup>b</sup> National Institute of Geophysics, Geodesy and Geography at the Bulgarian Academy of Sciences, Sofia, Akad.G.Bonchev St, bl. 3

Corresponding author's e-mail: sakazak@mail.bg

Newly launched Sentinel-2 satellites providing frequent and highly spatial resolution images emerged as powerful tool for environmental assessment of inland water bodies. The study used freely available satellite data for chlorophyll-a monitoring as main indicator of eutrophication process in small water bodies – Srebarna (roughly about 100 ha open water) and Malak Preslavets (roughly about 17 ha open water) situated in Lower Danube floodplain. Sentinel 2A MSI L1c products from 2017 were used in order of chlorophyll-a assessment in SeNtinel Application Platform (SNAP) using S2\_MCI and C2RCC (C2X neuronal nets) processors, resampled by 20 m pixel resolution. Maximum chlorophyll index (MCI) revealed typical unimodal seasonal curve in chlorophyll concentration with maximum values in august for both lakes. Considering its larger size Srebarna lake showed spatial heterogeneity in chlorophyll concentration at different parts of the lake. Highest concentration was registered in the Pelican pool (next to nesting colony of *Pelecanus crispus*) situated in the north part of the reed belt of the lake. On the other hand Malak Preslavets lake was sparsely covered by mats of floating vegetation resulting in a shrunk open water table, however sufficient for seasonal observation of maximum chlorophyll as well as data extraction. Average chlorophyll values in August 2017 retrieved by C2RCC processor for Malak Preslavets registered hypertrophic conditions - 68.83 (SD  $\pm 10.87$ ) mg.m<sup>-3</sup>. Nearly twice lower average values were registered from the open water table of Srebarna lake - 24.59 (SD  $\pm 5.37$ ) mg.m<sup>-3</sup>. *In situ* data from August 2012 showed controversy results regarding Malak Preslavets as rather eutrophic lake with values of 45.18 (SD  $\pm 12.45$ ) mg.m<sup>-3</sup> and Srebarna as hyperthrophic lake with 65.92 (SD  $\pm 17.12$ ) mg.m<sup>-3</sup>. Whether the shift in the trophic state of the both lakes obtained by satellite data is stable or rather temporary event would be clarified after *in situ* data comparison.

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**Keywords:** Sentinel 2 images, Lower Danube floodplain lakes, chlorophyll-a.

# **Morphological changes and their implication for management of a multi-thread river**

**Anna Kidová**

Institute of Geography, Slovak Academy of Sciences, Štefánikova 49, 814 73 Bratislava, Slovakia

Corresponding author's e-mail: geogkido@savba.sk

Long-term monitoring as well as the geomorpho-ecological quality status based on Water Framework Directive supports the desirable management and restoration works within the river basins. The study Belá River basin was incorporated into the international category of the "representative basin" by Slovak Hydrometeorological Institute and is registered in the framework of the International hydrological programme of UNESCO. The braided-wandering Belá River represents the biocorridor supraregional importance, where there is known occurrence of species of European as well as national importance. GIS-based multi-temporal analysis of aerial photos (seven time periods: 1949, 1961, 1973, 1986, 1992, 2003 and 2009) document the spatial and temporal changes in channel morphology and its vegetation cover. From the forties of 20th century the multi-thread Belá River reflects the general degradation of the former braided planform to wandering one. Regarding to previous results the braidplain narrowing relate with the river channelization and watershed afforestation between 1957 and 2008. The linkage between vegetation cover and channel landforms indicates the in-channel succession of vegetation and reflects a decreasing trend in active channel area due to river bed incision. The management challenges reflect the needs development of legislative for protective zones of Tatra Mountains National Park where the Belá River partly flows. Hydropower, rafting or fishing in existing ecosystem services scheme reveal the strong as well as weak opportunity for maintain its rare geodiversity for future generation. The potential development of geo-tourism in this area should help to knowledge spread around the region inhabitants and stakeholders as well.

The research was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences; 02/0098/18.

**Keywords:** management, Belá River, braided, multi-temporal, degradation

## Distribution of *Eurytemora velox* (Copepoda, temoridae) in the Danube River and new data from Bulgaria and Hungary: Is it an invasive or non-invasive alien species in the Danube?

Anita Kiss<sup>a</sup>, Stefan Kazakov<sup>b</sup>, Árpád Berczik<sup>a</sup>, Mária Dinka<sup>a</sup>, Edit Ágoston-Szabó<sup>a</sup>, Luchezar Pehlivanov<sup>b</sup>, Hristina Kalcheva<sup>c</sup>, Roumen Kalchev<sup>c</sup>

<sup>a</sup>Danube Research Institute, Centre for Ecological Research, Hungarian Academy of Sciences, Karolina út 29, 1113 Budapest, Hungary

<sup>b</sup>Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences Bulgaria, Sofia 1113, 2 Major Yurii Gagarin str.

<sup>c</sup>Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Tsar Osvoboditel Blvd. 1, 1000 Sofia, Bulgaria

Corresponding author's e-mail: kiss.anita@okologia.mta.hu, berczik.arpad@okologia.mta.hu, dinka.maria@outlook.hu, edit.agostonszabo@gmail.com, sakazak@mail.bg, luchezarpehlivanov@gmail.com, roumenkalchev@hotmail.com

*Eurytemora velox* is an originally saltwater Copepoda species, which tolerates a broad temperature and salinity spectrum. The first European distribution data of *E. velox* from freshwater habitats was mentioned by Giesbrecht and Schmeil (1898) from the estuaries of the North Sea and Damian-Georgescu (1966) from the Danube River. Up till now *E. velox* migrated not only in the Danube River, but almost whole Europe. In this paper the actual and historical data were reviewed from Austria, Bulgaria, Hungary, Romania and Slovakia which revealed the distribution of *E. velox* in the Danube and adjacent wetlands.

*E. velox* was found in four wetlands along Bulgarian section of Danube where 492 specimens were collected between 2010 and 2014. In Hungary 498 specimens were collected from ten different side-arms of Gemenc-Béda-Karapanca-Floodplains and the main arm of the Danube during the eight years sampling period (between 2002 and 2004, 2007 and 2009, 2012 and 2013). The frequency of occurrence of the species was much higher in Hungarian wetlands where 21 % of the samples contained *E. velox* against only 5 % of the samples from Bulgarian wetlands. In Hungary this species occurs between April and October, with maximum density of 150 ind 100 l<sup>-1</sup>, while in Bulgarian it was registered only between May and July with a maximum density 140 ind 100 l<sup>-1</sup> in May. The average density of the species was similar in both countries (Bulgaria: 20.55 ind 100 l<sup>-1</sup>, Hungary: 18.3 ind 100 l<sup>-1</sup>), but there were significant differences in the density values between the investigated wetlands in Hungary with a highest density in the plesiopotamal Mocskos-Danube and the paleopotamal Riha Lake.

According to our data *E. velox* forms more persistent populations in Hungarian compared to Bulgarian wetlands presumably due to the availability of suitable environmental conditions. On the basis of the published and our data, *E. velox* is a non-invasive alien species in the Danube in our days, since after an initial short invasion of this species which was observed in the beginning of the 1990s, the density of *E. velox* significantly decreased.

**Keywords:** *Eurytemora velox*, alien species, distribution patterns, Danube River

## **Restoration and management of Danube floodplain habitats in Slovakia – the assessment of pre-revitalization state based on benthic invertebrate communities**

**Igor Kokavec<sup>a</sup>, Emília Mišíková-Elexová<sup>b</sup>, Margita Lešťáková<sup>b</sup>, Miroslav Očadlík<sup>b</sup>, Soňa Ščerbáková<sup>b</sup>, Zuzana Vráblová<sup>b</sup>, Ferdinand Šporka<sup>b</sup>**

<sup>a</sup> Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, SK-84506 Bratislava, Slovakia

<sup>b</sup> Water Research Institute, Nábřežie arm. gen. L. Svobodu 7, SK-81249 Bratislava, Slovakia

Corresponding author's e-mail: igor.kokavec@savba.sk

The project is aimed to the restoration of the Danube inland delta in Slovakia which has been affected by an extensive river regulation, agriculture and forestry. These human interventions caused a reduction in the floodplain area and their separation from the main river channel. As a result, decline in the dynamics of water regime and increase in sedimentation has been identified as major treats to the Danube floodplains. To achieve favorable conservation status of these endangered habitats, hydrological regime will be improved by direct interferences in river side-arms. Efficiency of revitalization activities will be monitored on benthic invertebrates which were considered as good indicators of hydrological changes in aquatic environment.

In 2017, mostly small and wadeable side-arms were chosen to sample. Quantitative samples of benthic invertebrates were taken from six sites in two seasons. We identified almost 150 taxa inhabiting these sites. According the community structure, the sites were divided into four significantly different groups. Heterogeneity of macroinvertebrate communities was confirmed also by a high variability in the species richness and density. Floodplain index (FI) calculated on the basis of Polychaeta, Oligochaeta, Mysidacea, Isopoda and Amphipoda distinguished eopotamon and parapotamon communities. However, the FI based on Mollusca species pointed to worse conditions as it reached the level of parapotamon and plesiopotamon. Based on evaluation scheme developed for the main river channel, the ecological status of a majority of sites was identified as moderate. Only one site was in bad condition.

We found that small Danube side-arms provide a variety of habitats suitable for different communities of benthic invertebrates. However, few side-arms showed their predispositions to siltation in future. Therefore, the restoration of hydrological regime in the Danube floodplain is needed to prevent the siltation in side-arms and improve quality of these habitats for wider spectrum of aquatic fauna.

The study was supported by the projects LIFE14 NAT/SK/001306 and APVV-16-0253.

**Keywords:** river restoration, Danube inland delta, macroinvertebrate community, floodplain index.

## **DNA damage and histopathological alterations in liver and gills of common bream *Abramis brama* (L.) as biomarkers of the Danube River pollution**

**Jovana Kostić<sup>a,b</sup>, Stoimir Kolarević<sup>a</sup>, Margareta Kračun-Kolarević<sup>c</sup>, Zoran Gačić<sup>b</sup>, Božidar Rašković<sup>d</sup>, Vesna Poleksić<sup>d</sup>, Mirjana Lenhardt<sup>b,c</sup>, Branka Vuković-Gačić<sup>a</sup>**

<sup>a</sup> University of Belgrade, Faculty of Biology, Chair of Microbiology, Center for Genotoxicology and Ecogenotoxicology, Studentski trg 16, 11000 Belgrade, Serbia

<sup>b</sup> University of Belgrade, Institute for Multidisciplinary Research, Department of Natural Resources and Environmental Sciences, Kneza Višeslava 1, 11030 Belgrade, Serbia

<sup>c</sup> University of Belgrade, Institute for Biological Research “Siniša Stanković”, Hydrobiology and Water Protection, Bulevar despota Stefana 142, 11060 Belgrade, Serbia

<sup>d</sup> University of Belgrade, Faculty of Agriculture, Institute of Animal Science, Nemanjina 6, Zemun, 11080 Belgrade, Serbia

Corresponding author's e-mail: brankavg@bio.bg.ac.rs, lenhardt@imsi.rs, jkostic@imsi.rs, margareta.kracun@ibiss.bg.ac.rs, raskovic@agrif.bg.ac.rs

Biomarkers are used in ecosystem health assessment because they provide information about the biological effects of pollution. Aquatic ecosystems are often the ultimate recipients of different pollutants, which may have potentially genotoxic and carcinogenic effects on aquatic organisms.

The aim of this study was to assess the impact of untreated urban wastewater during different seasons on the DNA damage level and histopathological alterations in gills and liver of common bream (*Abramis brama*). This study was carried out at the site Višnjica, situated downstream from Belgrade, which is identified as one of the major hotspots of fecal pollution along the Danube River. Sampling was performed in February, April, August and November 2014. DNA damage in fish tissues was assessed by alkaline comet assay. Histopathological alterations were quantified by combining pathological significance and the extent for each lesion. Subsequently, lesion scores within organs are summed in order to calculate histopathological index.

The highest level of DNA damage in both tissues was observed in August. Liver had the lowest level of DNA damage in February, and gills in April. Gills had a significantly higher level of DNA damage in comparison to liver during all months, except in April.

Histopathological index of the liver had the highest values in April and of the gills in November. Both tissues had the lowest value of histopathological index in August. In general, histopathological alterations in liver were more severe in comparison to gills during all months, except in November.

The presence of DNA damage acted as an early-marker signal in fish, while histopathological alterations reflected state of fish organs when exposed to contaminants during long term pollution. This study confirmed the potential of untreated urban wastewaters to trigger responses on different levels of biological organization in fish.

**Keywords:** fish, biomarkers, comet assay, histopathology, urban pollution.

## Length-weight relationship and condition of three goby species in the Danube River near Slankamen (Serbia)

Jasmina Krpo-Ćetković<sup>a</sup>, Maja Prica<sup>a</sup>, Srđan Subotić<sup>a</sup>, Miroslav Nikčević<sup>b</sup>, Branislav Mićković<sup>b</sup>

<sup>a</sup> University of Belgrade, Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia

<sup>b</sup> University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11030 Belgrade, Serbia

Corresponding author's e-mail: ssubotic@bio.bg.ac.rs

Length-weight relationship and condition of 37 individuals of the monkey goby (*Neogobius fluviatilis*), 115 individuals of the round goby (*N. melanostomus*), and 40 individuals of the of racer goby (*Babka gymnotrachelus*), caught between July and October 2011 in the Danube River near Slankamen (1216.02 rkm), were analyzed, as well as the relative abundance of each species sample associated with particular sediment types. The average length ( $\pm$  S.D.) of the sampled individuals was  $8.76 \pm 2.05$  cm for the monkey goby,  $7.52 \pm 1.50$  cm for the round goby, and  $7.08 \pm 0.94$  cm of the racer goby. The average weight ( $\pm$  S.D.) of the sampled individuals were  $5.49 \pm 4.55$  g for the monkey goby,  $5.84 \pm 3.68$  g for the round goby, and  $3.62 \pm 1.78$  g for the racer goby. The regression coefficient of the length-weight relationship was  $b > 3$  for each species, which indicates a positive allometric growth. The highest average value of Fulton's condition factor was observed for the round goby ( $K = 1.2$ ), followed by the racer goby ( $K = 1.0$ ), and the lowest for the monkey goby ( $K = 0.7$ ). The monkey goby preferred sandy bottom, the round goby silty bottom, and the racer goby pebble bottom.

**Keywords:** length-weight relationship, Fulton's condition factor, allometric growth, bottom type, large river.

## Restoration strategies of the river connectivity in Slovakia focusing on the sturgeons in the Danube basin

Adriana Kušíková<sup>a</sup>, Ladislav Pekárik<sup>b</sup>

<sup>a</sup>Ministry of the Environment of the Slovak Republic, Nature, Biodiversity and Landscape Protection Directorate, Nature Protection Department, Námestie Ľ. Štúra 1, 812 35 Bratislava, Slovak Republic

<sup>b</sup>Plant Science and Biodiversity Center, Slovak Academy of Science, Dúbravská cesta 9, 845 23 Bratislava

Corresponding author's e-mail: [adriana.kusikova@enviro.gov.sk](mailto:adriana.kusikova@enviro.gov.sk), [ladislav.pekarik@savba.sk](mailto:ladislav.pekarik@savba.sk)

Danube population of the sturgeons follows a worldwide trend in the decline of sturgeons. Russian sturgeon (*Acipenser gueldenstaedtii*) and the beluga sturgeon (*Huso huso*) are on the brink of extinction in the Danube basin and without proper and urgent actions, they will share the fate with likely extinct ship sturgeon (*Acipenser nudiventris*). The pure freshwater species, the sterlet (*Acipenser ruthenus*) is the last remaining species in the Slovak stretch of the Danube River with the rapid decline of its stocks. Slovakia is a contracting party and a member of international and EU community with various obligations focusing on restoration and protection of wetland species, habitats and ecosystems (Convention on Wetlands of International Importance especially as Waterfowl Habitat, Convention on the Conservation of European Wildlife and Natural Habitats, Convention on cooperation for the Protection and Sustainable Use of the Danube River, Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy, etc.). Because of that, ensuring connectivity and restoration of wetlands (including riverine ecosystems) is part of main goals of many strategies. There is still a need of preservation and sustainable management of valuable aquatic ecosystems, wetland habitat restoration including river re-connection ensuring fish migrations and healthy productive rivers. The protection and recovery of riverine wetlands will prevent degradation of rivers in the future and create conditions for healthy aquatic ecosystem functions and benefits for humans.

**Keywords:** sturgeons, Danube River, habitat restoration, river connectivity, wetlands.

# **Insights into spatio-temporal changes in hydrological-sedimentary connectivity of the Slovak part of the Danube anabranching reach.**

**Milan Lehotský<sup>a</sup>, Igor Matečný<sup>b</sup>, Miloš Rusnák<sup>a</sup>**

<sup>a</sup> Institute of Geography, Slovak Academy of Sciences, Department of Physical Geography, Geomorphology and Natural Hazards, Štefániková 49, 814 73 Bratislava, Slovakia,

<sup>b</sup> Department of Physical Geography and Geocology, Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovakia

Corresponding author's e-mail: geogleho@savba.sk

The study reach of the Danube River it was characterized by meandering, anabranching and braided channels in the past Its damming in 1992 effectively abolished the active connection between the old main channel and its floodplain side arms, and water now has to be supplied to former side channels via an artificial recharge system. The aim of this research is to identify hydrological-sedimentary connectivity of channels and its changes from 1992, analyse spatiotemporal variability of bypassed channel narrowing, depict channel-new floodplain pocked sedimentary connectivity (vertical accretion) as response to different discharges and suspended load masses, demonstrate the changes in land cover diversity for a new floodplain pocked. Spatial data were generated from remote sensing images (aerial photographs and orthophotographs) in several time horizons (1980, 1986, 1990, 1996, 2003, 2010, 2011). For classification of the hydrological connectivity we worked out refined scheme taking into account discharge, flow velocity, nature of the river bed, width and depth of channels. According to these criteria, we identified the following categories of channels: 1) Eupotamal - A, B1, B2; 2) Parapotamal - A, B; 3) Plesiopotamal and 4) Paleopotamal. The bypassed Danube channel was qualitatively differentiated by the aggradation or degradation trend of its bed evolution. Changes in bank line were assessed by overlapping bank positions. Five cross-sections with 3 digging trenches across each of them and three cross-section with borings have been used for sediment sampling as well as for establishing a relative stratigraphy of accreted deposition-landform units through the floodplain pocked. Decreasing discharge and the disconnectivity in sediment fluxes due to the construction of the Čunovo dam in 1992 conditioned not only loss of hydrological connectivity of anabranching system and the main channel narrowing but also the grain size change in scroll bars vertical accretion stratigraphy and vegetation succession

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**Keywords:** connectivity, Danube, sediments, changes, land cover

## Measurement of coarse sediment connectivity in braided rivers

Milan Lehotský, Miloš Rusnák, Anna Kidová, Jozef Dudžák

Institute of Geography, Slovak Academy of Sciences, Štefániková 49, 814 73, Bratislava, Slovakia

Corresponding author's e-mail: geogleho@savba.sk

Our study presents a method that focuses on the long-term multitemporal assessment in potential coarse sediment connectivity (CSC) of braided-wandering channels as responses to six flood periods, which applies and combines both structural and functional approaches. To test the CSC, the modified habitat availability concept was applied, and the bars are considered as patches, and habitat patch connections are represented by bar links as potential sediment transport routes in downstream direction only. The tests were set on the braided-wandering Belá River characterized by a braided pattern as well as by a wandering, transitional channel form between braiding and meandering. The seven sets of remote sensing data (1949-2009) were used as basic information sources for the study of CSC along the braided-wandering Belá River. Conefor Sensinode 2.6 software using patch-graph theory was adopted as the tool for the assessment structural connectivity. The bar areas (connection nodes), 200 m direct links between them, and the attribute of deflection angle of a link to flow direction served as parameters for the estimation of the integral index of connectivity (IIC), bar area (BAI) and bar link (BLI) importance indices. The potential functional CSC is inferred from variability of values obtained by balance indices ( $B1$ ,  $B2$ ). Eight modifications of the potential functional CSC based on balance indices and the deduction of processes conditioning channel-floodplain and in-channel CSC linkages were identified. The coefficient of determination of IIC values was used for the interpretation of reaches behaviour in relation to flood periods. The higher values of IIC fit with a good developed bar system. Conversely, the values of IIC decrease due the progressive degradation of the braided pattern. Based on the coefficient of determination all reaches exhibit decreasing trend in IIC values and variable behaviour (from sensitive to robust). In general, CSC in the Belá braidplain in years 1949 – 2009 decreased due to both, internal and external drivers.

The research was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences; 02/0098/18.

**Keywords:** connectivity, coarse sediments, patch-graph, braided river

## Investigation of fish behavior at Iron Gate II Hydropower plant by acoustic telemetry

Mirjana Lenhardt<sup>a</sup>, Radu Suci<sup>b</sup>, Stefan Hont<sup>b</sup>, Gorčin Cvijanović<sup>a</sup>, Miroslav Nikčević<sup>a</sup>, Stefan Skorić<sup>a</sup>, Marija Smederevac-Lalić<sup>a</sup>

<sup>a</sup> Institute for Multidisciplinary Research University of Belgrade, Kneza Višeslava 1, 11000 Belgrade, Serbia

<sup>b</sup> Danube Delta Institute for Research and Development, 165 Babadag Street, 820112 Tulcea, Romania

Corresponding author's e-mail: lenhardt@ibiss.bg.ac.rs

The Iron Gate II HPP represents the first barrier for long migratory fish species (sturgeons, shads, eels) on their spawning migration from the Black Sea to the upstream parts of the Danube River. It was built in 1984 on rkm 864 while Iron Gate I HPP was built on rkm 943 in 1970, both without fish passages. The establishment of fish passages at the Iron Gate dams could provide access of migratory fish to the upstream 900 km long stretch of the Danube and its major tributaries. This study was performed as a part of activities in project "Fish behaviour preparatory study at Iron Gate Hydropower dams and reservoirs" financed by European Investment Bank with the main goal to test telemetry techniques in the vicinity of Iron Gate dams. Fish tagging was performed with Vemco V16 TP acoustic tags, equipped with temperature and depth sensors. Seven Vemco VR 2W receivers were installed on 7 - 8 April 2015 downstream the Iron Gate II HPP, along Serbian and Romanian banks. One catfish (*Silurus glanis*), with total length about 2 m and total weight about 100 kg, was tagged on April 28th 2015. Additionally, one specimen of barbel (*Barbus barbus*) and one specimen of asp (*Aspius aspius*) were tagged in the same year on November 6<sup>th</sup> and 11<sup>th</sup>, respectively. Asp and barbel were detected only in short period after releasing while catfish records lasted from 28 April, 2015 till 13 February, 2017. One beluga sturgeon, which was tagged in 2013 in Borcea branch (Danube rkm 300), was recorded on receivers in the vicinity of Iron Gate II during 2015. This research was the first attempt to investigate behavior of different fish species in the vicinity of Iron Gate II. It also point to problems of collecting reliable data for fish behavior in this area and need to solved them.

**Keywords:** migratory fish species, sturgeon, Vemco V16 TP acoustic tag, catfish.

## Water quality changes of the Slovak stretch of the River Danube

Jarmila Makovinská<sup>a</sup>, Lea Mrafková<sup>b</sup>

<sup>a</sup> Water Research Institute, Nábr. Arm. Gen. Svobodu 5, 812 49 Bratislava, Slovak republic

<sup>b</sup> Slovak Hydrometeorological Institute, Jeséniova 17, 833 15 Bratislava, Slovak republic

Corresponding author's e-mail: jarmila.makovinska@vuvh.sk, lea.mrafkova@shmu.sk

The Danube is international and transboundary river and therefore its water quality has been regularly monitored for a long time in its Slovak stretch. First water quality monitoring programmes with limited number of parameters and sampling points have already been established based on bilateral agreements with Austria and Hungary in sixties.

Later on national monitoring was established with focus on major source of pollution. In the year 1989 the extended water quality monitoring has started with regards to the Gabčíkovo structure water works. In general physico-chemical, chemical, microbiological, hydrobiological, microbiological and radiological parameters in monthly frequencies have been monitored. Based on the data available representing parameters have been selected to present development in the water quality of the Slovak stretch of the River Danube using three monitoring station (Bratislava, Medveďov, Szob).

**Key words:** Danube River, water quality, determinants

## **Status assessment of the River Danube within two management plans**

**Jarmila Makovinská, Elena Rajczyková**

Water Research Institute, Nábr. Arm. Gen. Svobodu 5, 812 49 Bratislava, Slovak republic

Corresponding author's e-mail: jarmila.makovinska@vuvh.sk

In connection with the EU Water Framework Directive (WFD, Directive 2000/60/EC) the assessment of ecological status, ecological potential and chemical status of surface water bodies was adopted in the frame of the river basin management plans. The first Slovak River Basin Management Plan (2009) has presented status assessment of the period 2007 -2008, while its update (2015) was represented by the period 2009 – 2012 (2013). Slovak stretch of the River Danube is divided into four water bodies from which two are characterized as natural and two as the heavily modified. Each of the water body has been monitored through representative monitoring station. The individual quality elements (biological, physico-chemical and hydro-morphological, specific substances) of the ecological status/potential evaluation as well as the assessment of 33 priority pollutants as the substances regulated on European level are compared within two river basin management planning cycles. Harmonization of the Danube river water bodies is also included based on the bilateral agreements.

**Keywords:** Danube River, WFD, status assessment, management plans

## **Extreme flood events in the Middle Danube – tracking changes of the ecological state applying the phytoplankton assemblage index**

**Melita Mihaljević, Alojzija Damjanović, Andrea Kolobarić, Dubravka Špoljarić Maronić**

Josip Juraj Strossmayer University of Osijek, Department of Biology, Cara Hadrijana 8A, 31000 Osijek, Croatia

Corresponding author's e-mail: dspoljaric@biologija.unios.hr

Extreme hydrological events, including snowmelt and rainfall floods, have become more frequent and intensive in the Danube River basin. This study aimed to evaluate the changes in the environmental condition of the Danube River caused by extreme flooding applying the phytoplankton functional approach. It was conducted at the middle Danube River section (river 1388 km) where the huge floodplain area of Kopački Rit (Croatia) had a significant positive influence on flood wave attenuation and reduction of flood risks downstream. We compared physical and chemical water properties and phytoplankton functional groups based on a monthly analysis in 2013, characterized by an extreme rainfall flood in June, with data for 2012 signifying more or less usual hydrological conditions. The yearly average values of nutrients, chlorophyll-a, total phytoplankton abundance and biomass were similar in both years. The dominance of diatoms from functional groups T<sub>B</sub> (benthic species) and D (single-celled eutrophic centrics) with a supplement of diatoms from groups C (mesotrophic centrics) and P (limnophilic meso-eutrophic pennates) characterised the phytoplankton communities, regardless of hydrological conditions. The phytoplankton assemblage index Q(r) values ranged between 2.48 and 4.49 indicating changes in ecological state ranging between poor and excellent. The lowest Q(r) value was observed in April 2013 when a significant nitrate concentration increase favored eutrophic species from the G group (green volvocaleans). After the extreme flood in June 2013, total phosphorus concentration significantly increased and phytoplankton biomass peaked. Due to the abundance increase of diatoms with benthic origin, which are considered a natural community in this river section, the Q(r) were as high as almost throughout the entire year. Altogether, it seems that extreme flood events should not alter the observed re-oligotrophication trend of the River Danube in its middle section.

**Keywords:** extreme floods 2013, potamoplankton, functional groups, Q(r) index.

## **Slovak Danube River Assessment Based on Intercalibrated Biological Method for Macroinvertebrates**

**Emília Mišíková Elexová, Margita Lešťáková, Soňa Ščerbáková, Matúš Haviar**

Water Research Institute, Slovak National Water Reference Laboratory, Nábr. Arm. Gen. Svobodu 5, 812 49 Bratislava, Slovak republic

Corresponding author's e-mail: [elexova@vuvh.sk](mailto:elexova@vuvh.sk)

With respect to the international and transboundary character of the Danube River, its water quality has been regularly monitored for a long time period. Several studies deal with macroinvertebrates of its Slovak 172 km long stretch which represent the indicative assemblage for water quality assessment. In connection with the EU Water Framework Directive (WFD, Directive 2000/60/EC) multimetric approach was adopted within ecological status assessment in natural water bodies (WB). Its main principle is a comparison of monitored situation with reference conditions. Slovak Republic developed such WFD compliant classification schemes for ecological status assessment, based on selected stressor specific metrics depending on Slovak rivers typology. The Slovak Danube River stretch was categorized as a special subtype of Very large river (of catchment area  $>10\,000\text{ km}^2$ ) within Pannonian Lowland ecoregion ( $<200\text{ m}$ ). The main river channel was subdivided into four water bodies – two natural and two heavily modified. New WFD approach of the Danube assessment has been applied since 2007. The first Slovak River Basin Management Plan (2009) is comprised of evaluated data of years 2007 and 2008. These data provided the database for the second phase of Intercalibration exercise, focused on Very large rivers. So-called XGIG Large River Intercalibration starting from 2009 was a process of intercomparison of the biological assessment methods for macroinvertebrates within relevant rivers and water bodies. It was prolonged to the 3. phase, relaunching in 2013. The upper section of the Danube River Slovak stretch fell into good status while the most of it was evaluated within moderate status. The following step within WFD European activities is a common understanding and harmonizing of methods for ecological potential assessment in heavily modified water bodies, concerning the Danube River as well.

**Keywords:** Danube River, intercalibration, macroinvertebrates, ecological status, WFD

## **One flew over the Danube floodplain lakes (Koviljski Rit wetland area): UAVs as promising tool in aquatic vegetation assessment**

**Maja Novković<sup>a,\*</sup>, Dušanka Cvijanović<sup>a</sup>, Milica Živković<sup>a</sup>, Ana Anđelković<sup>a,b</sup>, Bojan Damjanović<sup>a,c</sup>, Branislav Vesković<sup>d</sup>, Nikola Lukičić<sup>d</sup>, Snežana Radulović<sup>a</sup>**

<sup>a</sup> Department of biology and ecology, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića 2, 21000 Novi Sad, Serbia,

<sup>b</sup> Institute for Plant Protection and Environment, Belgrade, Serbia, Teodora Drajzera 9, 11040 Belgrade, Serbia

<sup>c</sup> Higher Medical and Business-Technological School of Applied Studies Šabac, Hajduk Veljkova 10, 15000 Šabac, Serbia

<sup>d</sup> Airworx, Heroja Pinkija 81, 21000 Novi Sad, Serbia

\*Scholar of Ministry of Education, Science and Technological Development of Serbia

Corresponding author's e-mail: maja.novkovic@dbe.uns.ac.rs,

Riverine habitats may support unique biodiversity, richer than the main river channel. However, regular monitoring of these complex habitats require time and cost consuming design. The UAVs (unmanned aerial vehicles) monitoring methods grow into a valuable tool in ecological assessment of riverine habitats, the wetlands especially.

The aim of this study was to test the usability of the macrophyte vegetation UAV imagery within monitoring of two Danube floodplain lakes (Koviljski Rit, river km 1231-1250).

The UAV images were collected in August of 2017. Two single flights of DJI Inspire1 drone were performed, taking pictures 110-115m above ground, each lasting 4-7 minutes. About 80 images per flight were taken using the 12MP Zenmuse X3 camera. Simultaneously, vegetation data were collected with circular plots 1-3m in diameter.

Images were stitched into two georeferenced orthomosaics covering together a total lake area of 7ha. The accuracy of georeferencing was additionally verified with 6 GCP (ground control points) per orthomosaic. The orthomosaics were processed and classified with supervised pixel- and object-based image classification approaches, in order to distinguish the dominant vegetation types. Three types of vegetation stands were recognized: i) water lilies dominated stands ii) stands characterized with hornwort and iii) free-floating duckweed species. Pixel-based semi-automatic classification produced good classification accuracy, having about 70% and 80% of overall accuracy, and 0.60 and 0.70 Kappa hat coefficient for two different test sites. Additionally, the supervised object-based classification was applied for the same test sites, producing the similar results.

The results proved the UAVs high spatial resolution imagery as promising tool for freshwater habitats ecological assessment.

**Keywords:** UAV (unmanned aerial vehicle), drone, image classification, photogrammetry, aquatic vegetation, wetland.

## **Floristic inventory and mapping of dry habitats along the Danube course in Croatia under the DANUBEparksCONNECTED project**

**Siniša Ozimec<sup>a</sup>, Dragan Prlić<sup>b</sup>, Vlatko Rožac<sup>c</sup>**

<sup>a</sup> Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture in Osijek, Vladimira Preloga 1, HR-31000 Osijek, Croatia

<sup>b</sup> Josip Juraj Strossmayer University of Osijek, Department of Biology, Cara Hadrijana 8/A, HR-31000 Osijek, Croatia

<sup>c</sup> Public Institution Nature Park Kopački rit, Mali Sakadaš 1, Kopačevo, HR-31327 Bilje, Croatia

Corresponding author's e-mail: [sozimec@pfos.hr](mailto:sozimec@pfos.hr)

Supported by the Danube Transnational Programme in the Danube Region, an Interreg project, entitled: Bridging the Danube Protected Areas towards a Danube Habitat Corridor (DANUBEparksCONNECTED, is implementing in period 2017-2019, with 15 partners from nine Danube countries. One of thematic activities is conservation and management of dry and semi-arid habitats along the Danube Habitat Corridor, with orchids as flagship species. Public Institution Nature Park Kopački rit in cooperation with external experts started in June 2017 activities about dry habitats along the Danube course in Croatia. The aim is to make the floristic inventory, mapping the spatial distribution, and estimate preservation of dry grasslands in the area of Nature Park Kopački rit and selected NATURA 2000 areas in Croatian Danube Region. The surveyed dry habitats are characterised as xeric grassland vegetation included in Annex I of the EU Habitat Directive under habitat codes: 6240 Sub-pannonic stepic grassland, and 6250 Pannonic loess steppic grasslands. Based on collected data from the field surveys and literature sources, a complete list of flora of dry habitats will be provided. The presence and population size of rare, endangered and protected plant taxa on dry grasslands will be determined, with a special view on members of the orchid family, and presence of non-native and invasive plant species. Implementation of project results will contribute to better knowledge on biodiversity of flora and ecological value of dry habitats in the Croatian Danube Region and the Danube Habitat Corridor.

**Keywords:** dry habitats, flora, Danube, Kopački rit, Croatia

## Regionalisation of the flood design values along The Danube River

**Pavla Pekarova<sup>a</sup>, Pavol Miklanek<sup>a</sup>, Jan Pekar<sup>b</sup>, Dana Halmova<sup>a</sup>, Veronika Bacova Mitkova<sup>a</sup>**

<sup>a</sup> Institute of Hydrology SAS, Bratislava, Slovakia

<sup>b</sup> Comenius University, Bratislava, Faculty of Mathematics, Physics and Informatics, Slovakia

One of the basic problems of the flood hydrology was – and still is – solving the relationship between peak discharges of the flood waves and probability of their return period. Importance of extrapolation derived from these variables (so called frequency curve) is especially necessary for proposal of water management and flood control plans. Directive 2007/60/ EC of the European Parliament of 23 October 2007 concerning the assessment and management of flood risks requires member States to draw up flood hazard maps of floods with very long return periods  $T$  (500- to 1000- years). In this study, the measured time series of the maximum annual discharge  $Q_{max}$  from selected 20 gauges of the Danube River were used for the estimation of the coefficients of the theoretical distribution functions. For the estimation of the distribution function we used only one distribution - the Pearson type III distribution with logarithmic transformation of the data (log Pearson type III distribution - LP3 distribution). We used only one distribution type because of the regionalization of the distribution skewness coefficient. Skewness coefficients of the LP3 distribution on Danube River vary between  $-0.404$  and  $0.861$ .

**Keywords:** floods, extreme discharge, Danube River

## UAV technology application in riverine landscape

Miloš Rusnák<sup>a</sup>, Ján Sládek<sup>a,b</sup>, Anna Kidová<sup>a</sup>, Milan Lehotský<sup>a</sup>

<sup>a</sup> Institute of Geography, Slovak Academy of Sciences, Bratislava, Slovakia

<sup>b</sup> GEOTECH Bratislava, s.r.o., Slovakia

Corresponding author's e-mail: geogmilo@savba.sk

Landform identification is normally based on the object classification framework using field work and remotely sensed data with temporal and spatial accessibility, flexibility and accuracy. The main aim is to present possibilities of UAV technology for the identification and mapping of fluvial landforms and analysing of the point cloud density after vegetation filtration in fluvial geomorphic research. Data acquisition for riverine landscape mapping using a low-cost UAV outlay is divided in to 5 main steps: (i) reconnaissance of the mapped site - identification of potential problems and dangers in flight mission, takeoff and landing points; (ii) pre-flight field work - the placement and targeting of ground control points (GCPs) for precise georeferencing; (iii) flight mission - aerial imaging of the study area; (iv) quality check and processing of aerial data - data accuracy assessment and software data processing and (v) operations above processed layers and landform (object) mapping (extractions) - comprising visualization, landform identification and morphometric analysis. The essential field research elements of legislative processes and UAV permission and regulations were certified prior to the flight; and these are designated step zero (0).

For monitoring of the selected Belá River reach was used UAV system from HiSystem company: HEXAKOPTER XL with 6 rotors and Sony NEX 6 camera with 16-50 mm lens. Spatial referencing was performed with 38 control points (GCP- Ground Control Point) targeted by RTK GPS Leica Zeno 5 with GG03 antenna and accuracy of 11 mm. For data processing was used Agisoft PhotoScan software, which operates on the principle of SfM algorithm. Advantages of this method is high level of automation and UAV photogrammetry provides accurate data with high resolution, affordable acquisition cost and represent the less time-consuming data collection technique. Total geometry error was 80 mm and RMSE (root mean square error) after aligning all the images it was 60.121 mm (x coordinate), 43.7584 mm (y coordinate) and 29.46 mm (z coordinate). In the areas with dense vegetation is obvious significant loss of information of the surface height. Multiple imaging by classic nadir images combined with oblique and horizontal ground imaging is crucial in mapping bank height, bank line, bluffs and valley walls. The accuracy of the applied classic approaches to bank delimitation from aerial photos in both models and orthophotos is severely affected when the banks are inclined at an angle rather than forming a vertical cliff. It is therefore important to create a methodology which applies landforms delimitation in 3-dimensional space; employing 3D assessment of landscape objects rather than classic planar geoscience analysis in GIS.

The research was supported by Science Grant Agency (VEGA) of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences; 02/0098/18.

**Keywords:** UAV, fluvial landscape mapping, workflow, point cloud classification, vegetation separation, UAV photogrammetry

## Growth parameters of vimba bream (*Vimba vimba*) in the Danube River near Belgrade (Serbia)

Srđan Subotić<sup>a</sup>, Milica Gavrilović<sup>a</sup>, Željka Višnjić-Jeftić<sup>b</sup>, Jasmina Krpo-Četković<sup>a</sup>, Mirjana Lenhardt<sup>c</sup>

<sup>a</sup> University of Belgrade, Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia

<sup>b</sup> University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11030 Belgrade, Serbia

<sup>c</sup> University of Belgrade, Institute for Biological Research „Siniša Stanković“, Bulevar despota Stefana 142, 11060 Belgrade, Serbia

Corresponding author's e-mail: ssubotic@bio.bg.ac.rs

Age, growth, and length-weight relationship of the vimba bream (*Vimba vimba*) were analysed on a sample of 43 individuals from a commercial catch, caught between March and May 2017 in the Danube River near Belgrade. Total body length of the sampled fish ranged from 26.3 to 34.5 cm, and body weight from 223 to 554 g. Age of the sampled fish, determined from scales, ranged from 5+ to 8+, with the largest percentage of individuals in the age class 6+. The regression coefficient of the length-weight relationship was  $b = 3.28$ , which indicates a positive allometry. The parameters of the von Bertalanffy function were  $L_{\infty} = 543.82$ ,  $K = 0.09$ , and  $t_0 = -2.41$ . The estimated phi-prime growth performance index ( $\phi'$ ) was 4.44. The Fulton's condition factor ranged from 1.04 to 1.42, with the mean value of 1.23. The length-at-age was back-calculated with the method of Monastyrsky, and the greatest relative growth increment was observed during the first two years of life.

**Keywords:** length-at-age, condition factor, length-weight relationship, allometric growth, back-calculation, large river.

## Age, growth, and length-weight relationship of common nase (*Chondrostoma nasus*) in the Danube River near Belgrade (Serbia)

Srdan Subotić<sup>a</sup>, Željka Višnjic-Jeftić<sup>b</sup>, Jasmina Krpo-Ćetković<sup>a</sup>, Mirjana Lenhardt<sup>c</sup>

<sup>a</sup> University of Belgrade, Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia

<sup>b</sup> University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 11030 Belgrade, Serbia

<sup>c</sup> University of Belgrade, Institute for Biological Research „Siniša Stanković“, Bulevar Despota Stefana 142, 11060 Belgrade, Serbia

Corresponding author's e-mail: ssubotic@bio.bg.ac.rs

Growth parameters, length-weight relationship, and condition of the common nase (*Chondrostoma nasus*) in the Danube River near Belgrade were analysed on a sample (n=30) from the commercial catch, caught between March and May 2017. The total body length of the sampled individuals ranged from 26.8 to 40.1 cm, and body weight from 195 to 875 g. Age was determined from scales and individuals aged 5+, 6+ and 7+ were present in the sample, in approximately the same percentage. The regression coefficient of the length-weight relationship was  $b = 3.28$ . The value of  $b > 3$  indicates a positive allometry, which denotes that the weight growth rate is greater than the length growth rate. The Fulton's condition factor ranged from 0.90 and 1.36, with the mean value of 1.07. The parameters of the von Bertalanffy function were  $L_{\infty} = 697.84$ ,  $K = 0.08$ , and  $t_0 = -1.72$ . The estimated phi-prime growth performance index ( $\phi'$ ) was 4.60. The lengths were back-calculated using the method of Monastirsky, and the greatest relative growth increment was observed in the first and second year of life.

**Keywords:** length-weight relationship, condition factor, length-at-age, back-calculation, allometric growth, large river.

# Restoration of the urban oxbow lake Alte Donau: Response of zoo- and phytoplankton to trophic alteration from hypertrophic to mesotrophic conditions over 22 years

Katrin Teubner<sup>a</sup>, Monika Großschartner<sup>b</sup>, Wilfried Kabas<sup>c</sup> and Irene Teubner<sup>d</sup>

<sup>a</sup> Department of Limnology & Biological Oceanography, Faculty of Life Sciences, University of Vienna, Austria

<sup>b</sup> DWS-Hydro-Ökologie GmbH, Vienna, Austria

<sup>c</sup> Vienna, Austria

<sup>d</sup> Department of Geodesy and Geoinformation, Faculty of Mathematics and Geoinformation, Vienna University of Technology, Vienna, Austria

Corresponding author's e-mail: [katrin.teubner@univie.ac.at](mailto:katrin.teubner@univie.ac.at)

Alte Donau was cut off from the Danube River for more than 160 years and is most popular for recreation and angler (cyprinid-dominated shallow water). This groundwater seepage lake, however, changed from mesotrophic in the eighties to hypertrophic in the nineties. The chemical restoration started in the nineties with drastic phosphorus reduction by phosphate precipitation (RIPLOX treatment). The low phosphate concentration was sustained in the following years by large effort of lake management. As in-lake treatment, the successful replanting of underwater vegetation was of decisive importance. Fish was at no time removed by other measures than angler sport. Nevertheless, fish management was slightly adjusted to support restoration effort (total fish stocking was 6157kg with 40% predatory fish in 1994, reduced stocking by 4347kg/year with 21% predatory fish during sustained lake management 2017-2014). As the phytoplankton shifted from a cyanobacteria dominated assemblage (*Cylindrospermopsis raciborskii*) under hypertrophic conditions to an assemblage that was composed of taxa of various taxonomic affiliations (mainly eukaryotic as chlorophytes, charophytes, ochrophytes), the chlorophyll-a content varied considerably. It reached its lowest value of 0.19% when cyanobacterial bloom was contributing 77% to total phytoplankton and was highest with 0.83% during the peak development of chlorophytes which contributed 18% to total biovolume (long-term median of chlorophyll-a content was 0.50% of wet weight phytoplankton biomass). Concomitantly to phytoplankton changes, the large-bodied zooplankton shifted from a community composed of mainly filter-feeding herbivorous cladocerans under eutrophied algal-turbid conditions to mainly selective-feeding omnivorous and herbivorous copepods under mesotrophic transparent-water conditions. During the sustained restoration period of successfully re-covered macrophytes, the carbon ratio of phytoplankton to zooplankton increased indicating an enhanced phosphorus utilization efficiency under low total phosphorus pool. Alte Donau thus provides an example of successful lake restoration mainly accomplished by bottom up (resource-driven) control rather than by top down (consumer-driven) control.

**Keywords:** Lake management, phytoplankton composition, zooplankton composition, cyanobacteria, cladocerans, copepods, chlorophyll-a to TP ratio.

## **Invasive alien species in the Danube Region and DIAS activities towards strategy development**

**Teodora Trichkova<sup>a</sup>, Florian Ballnus<sup>b</sup>, Aljoša Duplić<sup>c</sup>, Momir Paunović<sup>d</sup>, Doru Bănăduc<sup>e</sup>, Gábor Guti<sup>f</sup>, Csaba Csuzdi<sup>g</sup>, Rumen Tomov<sup>h</sup>, Vladimir Vladimirov<sup>a</sup>, Dan Cogălniceanu<sup>i</sup>**

<sup>a</sup> Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 1 Tsar Osvoboditel Blvd., Sofia 1000, Bulgaria

<sup>b</sup> Bavarian State Ministry for the Environment and Consumer Protection, Priority Area 06, EU Strategy for the Danube Region, Munich, Germany

<sup>c</sup> Karlovac University of Applied Sciences, Trg Josipa Jurja Strossmayera 9, Karlovac, Croatia

<sup>d</sup> University of Belgrade, Institute for Biological Research ‘Siniša Stanković’, Bulevar Despota Stefana 142, 11060 Belgrade, Serbia

<sup>e</sup> Faculty of Sciences, ‘Lucian Blaga’ University of Sibiu, 5-7 Dr. Ion Rațiu Street, 550012 Sibiu, Romania

<sup>f</sup> MTA CER Danube Research Institute, Karolina u. 29, 1114 Budapest, Hungary

<sup>g</sup> Department of Zoology, Eszterházy Károly University, Eger, Hungary

<sup>h</sup> Department of Plant Protection, University of Forestry, 10 Kliment Ohridski Blvd., 1797 Sofia, Bulgaria

<sup>i</sup> Faculty of Natural and Agricultural Sciences, ‘Ovidius’ University of Constanța, Aleea Universității nr. 1, Campus B, 900470 Constanța, Romania

Corresponding author’s e-mail: trichkova@gmail.com

The introduction and expansion of invasive alien species (IAS) in Europe have increased recently. As a result, the biodiversity and ecosystems in different regions, including the Danube Region, are affected severely, and adverse socio-economic impact and impact on human health have been documented. The European Union (EU) Strategy for the Danube Region acknowledges IAS as a major threat to biodiversity and livable Danube Region. One of its targets as defined in Priority Area 06 states that ‘By 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS’. The EU Regulation No 1143/2014 on the prevention and management of the introduction and spread of IAS is in force since 2015, and a list of 49 invasive alien species of EU concern has been adopted. The International Commission for the Protection of the Danube River has proposed 30 alien species to be included in the ‘black list’ for the Danube River Basin.

Here we present some results of the recently conducted projects with participation of the Danube River Invasive Alien Species Network (DIAS): ‘Pilot-study (data collection) on invasive alien species in the Danube Region with a smartphone application developed by the Joint Research Centre (JRC) (Danube-IASapp project)’ (2016-2017), and ‘East and South European Network for Invasive Alien Species – A tool to support the management of alien species in Bulgaria (ESENIA-TOOLS)’ (2015-2017). Furthermore, we present the activities of DIAS towards development of the IAS strategy and work plan for the Danube Region within the frame of the Priority Area 06 of the EU Strategy for the Danube Region.

**Keywords:** Invasive alien species, priority species, the Danube Region, strategy, DIAS.

# Monitoring of the endocrine disruptor pesticides from water samples using immuno-affinity interaction – pre-treatment and analysis

**Madalina Tudorache**

University of Bucharest, Department of Organic Chemistry, Biochemistry and Catalysis, Bucharest 030016, Romania

Corresponding author's e-mail: madalina.sandulescu@g.unibuc.ro

Our laboratory proposes an efficient system for pre-treatment and analysis of water samples. The working principle is called Immuno-supported liquid membrane (ISLM) extraction. ISLM is a new technique that makes use of antibody (Ab)–antigen interactions as the “extraction force” to drive the mass transfer in a selective way. In immuno-SLM, anti-analyte (Ag) Abs are introduced into the acceptor phase of the SLM unit to trap the Ag that passes from the flowing donor through the SLM into the stagnant acceptor. The amount of immuno-extracted analyte (AbAg) is quantified by connecting the immuno-SLM unit on-line with a non-competitive heterogeneous immunoassay (IA) titrating the residual excess of Ab present in the acceptor with the analyte tracer (*e.g.* HRP and EDF marker).

Factors influencing the efficiency of ISLM extraction, *i.e.*, donor flow rate, extraction time and type of Ab, were investigated for the model analytes atrazine and 2,4,6-trichlorophenol.

For atrazine, the concentration at the mid-point of the calibration curve (IC<sub>50</sub>) was 16.0±1.4 and 36±16 µg/l, the limit of detection (LOD) was 2.0±1.1 and 20±10 µg/l, and the dynamic range was 2–100 and 20–500 µg/l atrazine for ISLM and IA, respectively. The matrix influence on the IA was significant for surface water, whereas the influence was minor for ISLM with recoveries between 104% and 115% for 5 µg/l atrazine river water.

For trichlorophenols, the ISLM configuration leads to improved assay sensitivity (LOD 27.92±2.44 and 224±5.86 µg/L for ISLM and IA, respectively). Additionally, selectivity and recovery were improved for 2,4,6-TCP in presence of other chlorophenols (*e.g.* 2,4,5-trichlorophenol and 4-chlorophenol) compared to IA alone.

Versatility of the developed system allows performing similar monitoring for other compounds from endocrine disruptors class (*e.g.* dioxin, bis-phenol A, alachlor, etc). The main advantage of ISLM extraction system is the performance of cleanup of the sample and enrichment of the target analyte in one single step. Moreover, the extracted analyte is easily detected and quantified based on immune-affinity interaction Ab-Ag affording good sensitivity and selectivity of the analysis.

**Keywords:** endocrine disruptors, atrazine, antibody, extraction, enrichment, water sample.

***Book of Abstracts***

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