



12th DANUBE ACADEMIES CONFERENCE

Slovenian Academy of Sciences and Arts



LJUBLJANA
2023

DANUBE 
ACADEMIES 
CONFERENCE 

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**12th DANUBE ACADEMIES CONFERENCE (DAC)
October 18th – 20th, 2023, Ljubljana**

Book of Abstracts

Organized by:

**European Academy of Sciences and Arts
Slovenian Academy of Sciences and Arts**

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PROGRAM

Wednesday, October 18th, 2023

- *Arrival and accommodation of participants* at the Best Western Premier Hotel Slon, Slovenska cesta 34, Ljubljana, [Best Western Premier Hotel Slon Ljubljana Slovenia](#)

18:30 Welcome reception at Hotel Slon

19:00 Dinner

Thursday, October 19th, 2023

- *Scientific Program*

Friday, October 20th, 2023

- *Excursion*

12th Danube Academies Conference (DAC)

Thursday, October 19th, 2023

9.00–10.00 Registration

10.00–10.15 *Opening Address of the Conference (Venue: Main Academy Hall, Novi trg 3/I)*

Peter Štih, President of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia

Klaus Mainzer, President of the European Academy of Sciences and Arts, Salzburg, Austria

Part I, Chair: Branko Stanovnik, Slovenian Academy of Sciences and Arts

10.20 Martin Grambow (Bavarian State Ministry for the Environment and Consumer Protection, Technical University of Munich (TUM), Germany)

Impact of antropogenic land use on the regional water balance

10.50 Mihael Brenčič (University of Ljubljana, Faculty of Natural Sciences and Engineering, Slovenia)

Water resources in Slovenia

11.15 Franci Gabrovšek (Karst Research Institute SRC SASA, Slovenia)

The evolution and characteristics of karst aquifers

11.40 Nataša Viršek Ravbar (Karst Research Institute SRC SASA in cooperation with Slovenian Forestry Institute)

Is the recharge of karst aquifers influenced by large-scale forest disturbances?

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- 12.05 Bojan Mohar (Department of Mathematics, Simon Fraser University, Canada, Department of Mathematics, University of Ljubljana)
Slovenia Modelling karstic aquifers using network theory
- 12.30 Milan Radulović (Committee for Geology and Geography, Montenegrin Academy of Sciences and Arts; Faculty of Civil Engineering, University of Montenegro)
Karst hydrogeology of Montenegro
- 12.55–14.30 LUNCH BREAK
- Part II, Chair: Franci Gabrovšek, Slovenian Academy of Sciences and Arts*
- 14.30 Milena Horvat (Department of Environmental Sciences, Jožef Stefan Institute, Slovenia)
Source apportionment and fate of metals in river ecosystems due to anthropogenic and climate change forcing
- 14.55 Lenka Hagarová (Institute of Geotechnics, Slovak Academy of Sciences)
Advanced technologies for the contaminated water treatment to protect the largest natural groundwater reservoir in Central Europe - Rye Island
- 15.20 Andreja Žgajnar Gotvajn (University of Ljubljana, Faculty of Chemistry and Chemical Technology, Slovenia)
Emerging micropollutants in wastewaters: removal trends and perspectives
- 15.45 Tanja Ćirković Veličković (Serbian Academy of Sciences and Arts)
Seafood contamination with microplastics: analytically challenged global problem
- 16.10–16.30 COFFEE BREAK
- 16.30 Ina Aneva (Bulgarian Academy of Sciences)
The biodiversity in the Bulgarian sector of the Danube River – status, main threats, and challenges
- 16.55 Jovan Despotović (Serbian Academy of Sciences and Arts)
Information to the authorities and local people along the river Danube concerning the flood regime of rivers at the basin – An empirical evaluation
- 17.20 Dmitry Grummo (Director of the State Scientific Institution "Institute of Experimental Botany named after V.F. Kuprevich of the National Academy of Sciences of Belarus")
Disturbed Peatlands Restoration Experience in Belarus
- 17.45–18.00 *Conference end with communiqué*
- 19.00 Dinner at Restaurant Šestica (Slovenska cesta 40)

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Friday, October 20th, 2023

9.00 Excursion to Postojna – a visit to the Karst Research Institute in Postojna and the Postojna Cave.

The bus will leave from the Hotel Slon at 9.00 am and return to Ljubljana between 16.00 and 17.00 pm.

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OPENING ADDRESSES OF THE CONFERENCE

Peter Štih, President of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia

Esteemed presidents and representatives of the Danube academies,
Dear participants, ladies and gentlemen.

It is my pleasure to welcome you at the 12th Danube Academies Conference in Ljubljana and at the Slovenian Academy of Sciences and Arts. Especially since this year's conference coincides with the eighty-fifth anniversary of the founding of our Academy, which we will celebrate in the beginning of November.

Therefore I would like to begin my address with a brief presentation of the Slovenian Academy of Sciences and Arts. It was established in 1938, but it was, by no means, the first academy on Slovenian territory. This was the *Academia operosorum*, the academy of the diligent. Inspired by Italian academies, it was established in 1693 in Ljubljana and would celebrate its 330th anniversary today, but it ceased to work after a few decades. Its members, lawyers, theologians and physicians, have chosen the words *nobis atque aliis* as their motto. The maxim that work in the field of science should be for the benefit of the domestic, in our case Slovenian community and for the general good is so timeless and universal that it is also the foundation of the work of the Slovenian Academy. In this sense, we consider ourselves as the successor of the *Academia Operosorum*, although there is no direct link between the two academies.

The Slovenian Academy is the highest scientific and artistic institution in the country by law and currently has 96 full and associate members and 85 corresponding members from abroad, working in six sections. The SASA also nominates external experts to different Academy working bodies, such as the Council for Energetics, Council for the Protection of Environment, and the Council for Development, which was recently established as a platform for broader expert discussions on issues related to Slovenia's long-term development. Otherwise, the Academy's main tasks include addressing fundamental issues in science and arts, participating in the formation of research policy and artistic creation, developing international cooperation in the fields of sciences and arts, providing science-based advice to political decision makers and, last but not least, promoting sciences and arts.

To this end, we organise various conferences, symposia, round tables, lectures and debates on national and international level. To illustrate, in September alone, we organised a panel on the introduction of artificial intelligence to Slovenian schools, which addressed a very relevant topic, a symposium on lexicography as a part of our ongoing care for the Slovenian language, to which we devote a great deal of attention, further an international colloquium on art in Slovenia between the periphery and the centre in the early modern period; and finally a lecture on basic molecular biology.

I should also mention the Academy publishing activities and international cooperation, which are also an important part of our activities. In addition to the

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Academy Yearbook, containing annual reports on Academy activities, we also publish serial publications of individual Sections, symposia and conference proceedings, periodical publications, among which, also with regard to today's conference, I would like to highlight the internationally highly profiled journal *Acta Carsologica*, as well as extraserial publications of Academy members.

The Slovenian Academy of Sciences and Arts currently has in place 45 bilateral agreements of scientific cooperation, mostly with European academies. It is also a member of a number of academies associations. We cooperate more extensively mainly with academies in the region, namely with academies in neighbouring countries and with academies in the former Yugoslav republics. It is a particular pleasure for me to mention here our excellent cooperation with the European Academy of Sciences and Arts, with which we have also organised today's conference on the subject of "water".

Ladies and gentlemen, water is a word most closely linked to life. It is one of our planet's most important and absolutely indispensable goods. It is therefore not surprising that humankind has always paid great attention to it. Today, in a time of increasingly acute climate changes, growing pollution and poisoning of our environment, this is an even more urgent task. Today's conference is therefore just one of many, that are in one way or another related to water, which in our case has also a special symbolic meaning, since it is water – of course I am referring to the Danube – that binds our academies.

One of the many challenges we are facing is the protection of the environment and preservation of natural water resources. Climate change, pollution and inadequate management of water sources affect water-dependent ecosystems, as well as our health and wellbeing. Access to safe and clean drinking water is still not assured for all and the outlook for the future is not optimistic. This is the great challenge we face. Flood risk is another pressing challenge. This August, Slovenia has experienced firsthand, the scope of damage flooding may cause. It is measured in billions of Euros, with restoration work likely to last for years and the consequences, such as diverting money from investment to reconstruction, will be felt by society as a whole, not just by those directly affected by the floods. As a source of energy, water also has an important place in the context of reducing the use of fossil fuels, lowering carbon dioxide emissions and the transition to a carbon-free society. Unlike wind and solar energy, water is a constant and stable source of electricity. This is its greatest advantage, although its use has, of course, many limitations.

Science has a crucial role to play in addressing these problems and challenges, which can only be successfully solved through a scientific approach. This is where today's conference wishes to contribute, and I wish it every success.

Finally I have only the pleasant duty to thank Professor Branko Stanovnik, Head of our Department of International Relations and Scientific Coordination for the successful organisation of today's conference. I would also like to thank all those who helped in its preparation and wish all our guests a pleasant stay in Ljubljana.

Thank you very much.

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Klaus Mainzer, President of the European Academy of Sciences and Arts, Salzburg, Austria

Dear colleagues, ladies and gentlemen,

It is a great pleasure for me to open this year's Danube Conference. As president of the European Academy of Sciences and Arts, I bring you the greetings of the entire Academy. As you know, the Danube Conferences are closely linked to the ideals of the European Academy of Sciences and Arts (EASA) - to use the diversity of European countries and cultures for common developments in science and art.

What could be more obvious than to use the Danube as a unifying bond of nature to link the various national academies located on this great European river to jointly moving thematic conferences. I would like to take this opportunity to thank the Slovenian Academy of Sciences and Arts and its President for hosting this year's Danube Conference.

This year, the Slovenian Academy of Sciences and Arts, together with EASA, has focused on the theme of "Water". During this presidency of EASA, the topic of "water" has already been dealt with in detail in an Academy expert group on "Climate, Environment and Energy" and considered in an Academy position paper, which was also recently published in the Academy's new journal.

The technical, ecological and economic potentials of hydropower are obvious. Next to fire, hydropower is one of mankind's oldest forms of energy, which has been used in Europe in particular since time immemorial. Since the beginning of the 20th century, hydropower generation has been considered reliable, controllable and storable.

Since the end of the last century at the latest, however, ecological considerations have also come to the fore. The use of hydropower can damage ecosystems in the short and long term. In the past, effectiveness and maximisation of hydropower in large hydropower plants were considered exclusively desirable. The dammed areas set up for this purpose can have a positive impact on the landscape and be used, for example, as recreational areas near urban centres. On the other hand, the establishment of such hydropower plants can also severely disrupt nature conservation and biodiversity. In the sense of complex system dynamics, global ecological effects can thus be triggered by such local measures. Therefore, hydropower has to be carefully assessed taking into account e.g. river ecology, nature conservation, biodiversity and social use. Last but not least, the non-linear feedbacks of these factors must be kept in mind.

Hydropower is undoubtedly renewable and therefore an important part of the overall European strategy for energy use. However, there is also the intrinsic value of water landscapes from an ecological and cultural point of view. Non-linear interactions can trigger conflicts of objectives for renewable energies. On the one hand, there is the European requirement to significantly reduce greenhouse gas emissions by 2050 and to do so by 2030. Renewable energies such as hydropower should contribute to

this climate target. On the other hand, the protection goal of ecosystems must be taken into account, which must be able to recover even after interventions. The corresponding complex natural system must therefore be resilient in the sense of complex system dynamics.

At the European level, the requirements of nature conservation and water ecology have been significantly strengthened in recent years. Innovations in hydropower technology must be designed according to the imperatives of ecological sustainability. Practical recommendations for planners, authorities and operators are to be developed and implemented on the basis of scientific findings.

Ecosystems of water bodies are subject to complex system dynamics, the stability of which is a considerable challenge under the utilisation pressure of renewable energies. Existing infrastructures for the use of hydropower should therefore continue to be used from an ecological point of view. One example is the environmentally compatible expansion of existing large hydropower plants. However, the supposedly climate-friendly energy aspect of hydropower should be put on the back burner where water landscapes need to be safeguarded for future generations in terms of sustainability.

In an overall portfolio for Europe, the advantages and disadvantages of e.g. solar and wind energy, hydropower, hydrogen, nuclear and fusion energy must be weighed against each other and combined in a "hybrid" energy system. In this sense, water must also be oriented towards a sustainable future in an overall European portfolio. In this portfolio, diversity must ensure resilient behaviour in order to be able to react flexibly to the risks of the future and to recover overall in the event of selective setbacks.

I wish the conference exciting presentations and fruitful discussions that will have an impact on our academies.

References:

- EASA Position Paper of the EASA Expert Group „*Climate, Environment and Energy*“, in: PEASA (Proceedings of the European Academy of Sciences Arts) No. 1 2023
- Klaus Mainzer, *Zukunft durch nachhaltige Innovation im Wettkampf der Systeme*, Springer-Gabler: Wiesbaden 2023

L 1: IMPACT OF ANTROPOGENIC LAND USE ON THE REGIONAL WATER BALANCE

Prof. Dr.-Ing.-Martin Grambow, Bavarian State Ministry for the Environment and Consumer Protection, Technical University of Munich (TUM), Germany

The Anthropocene Earth Age is more than a description of a state. It is rather a new understanding of the rules of the biological, technical and social systems that determine our lives. The resulting challenges can only be mastered with knowledge about the systems themselves, their dynamics and stability requirements. This is where the theory of resilience comes in, which describes the behaviour of feedback-connected, complex systems. Such systems are difficult to decipher: possible overstepping of tipping points of often inconspicuous subsystems can have devastating and often delayed effects on the whole.

In recent centuries, massive changes have been made to the landscape, such as the draining of moors and wetlands, the installation of extensive drainage and channel systems for drainage, the construction of road networks with accompanying channels and also the area sealing through settlement and industrial development. Local transformations accumulate successively to systemically relevant effects. The structural changes to the landscape, which are only partially documented, were established in Bavaria over decades with the aim of drainage due to water availability. These adapted systems are now increasingly producing negative primary and secondary consequences that negate the actual primary purpose. Thus, the priority is now tipping from landscape drainage to storage and water distribution systems. Both effects, water overflow and drought, threaten an increasingly extensive and specialised or industrialised land management. System complexity increases due to the need to adapt to several determining load cases and also to new weather phenomena, such as flash droughts.

When considering the overall system of the regional water balance, it is remarkable that not all components have yet been scientifically researched. However, with a lack of water in various places and increasing demands for use, it is essential that all water-influencing components can be quantified in terms of their importance. For example, the symbioses of soil organisms and plants, the interactive effects of different land uses on the local climate and the consequences of new weather phenomena on regional water budgets must be investigated. In particular, forests are facing inevitable drastic changes in the course of the current strong focus on CO² storage and adaptation to climate change (temperature and drought). The impact of large forest areas, such as the Amazon and the boreal forests, on water budgets has been documented. But more and more the question arises, what influence do forests have on regional water balance and especially on precipitation and cloud formation. This question must be answered before large-scale forest areas are damaged or further developed for the following decades.

L 2: WATER RESOURCES IN SLOVENIA

Prof. Dr. Mihael Brenčič, Department of Geology, Natural Sciences and Engineering Faculty, University of Ljubljana & Geological Survey of Slovenia; associate member of SASA

Slovenia is geographically located in an area where humid Mediterranean cyclones (especially the Genoese anticyclone) cross with the humid Atlantic air flow from the northwest. This creates meteorological conditions favourable for intense and short convective summer precipitation and longer frontal precipitation, later especially in the autumn months. In addition to meteorological conditions, orographic influences resulting from the geological features of the region also play a role. Due to the relief of the region, there are two mountain barriers where most precipitation falls due to the rapid rise of moist air along the steep slopes and the direct effect of the barriers. The first orographic barrier is the Dinaric Mountains, which begin in southwestern Slovenia with the Karst Plateau and the Trnovo Banjška Plateau, and then continue in a SE direction to Croatia. The second is the alpine mountain barrier, the Southern Alps, which extends to the north of the country in the wider border area with the Republic of Austria. In these mountain ranges, snow accounts for a significant part of precipitation, and its thickness and duration are gradually decreasing due to climate change. This situation leads to high precipitation gradients, which means that the amount of precipitation varies over relatively short distances. In the highest parts of the Posočje region, the annual precipitation exceeds 4000 mm and then gradually decreases towards the interior. In the central part of Slovenia, the average annual precipitation is about 1500 mm, while in the northwest, in Pomurje, which forms an edge of the Pannonian Plain, the average annual precipitation is about 850 mm.

This distribution of precipitation creates favourable conditions for runoff. According to data from the Environmental Agency of the Republic of Slovenia, which is responsible for the management and definition of the national water balance, the average annual precipitation at the national level in the last balance period 1971-2000 was 1579 mm, evapotranspiration, i.e. the loss of precipitation, was 717 mm, and runoff was 862 mm. The average measured specific runoff of the country is 27 l/s/km², which corresponds to the discharge of 547 m³/s, and the average measured runoff coefficient is 53%. In this context, it is worth mentioning the groundwater runoff, which is 297 mm/year, corresponding to a discharge of 192 m³/s, and the rest of 565 mm/year or corresponding to the net surface runoff of 355 m³/s. In terms of water availability per capita, Slovenia receives 14,000 m³ of precipitation per capita per year, while runoff is 9,000 m³. According to the National Water Balance, these parameters place Slovenia above the global and European average, and the World Bank ranks Slovenia 54th in terms of water availability per capita. From this point of view, we consider Slovenia as water rich area.

When considering the hydrological conditions of a country and analysing the relationship between surface and groundwater, we must take into account the geological conditions in the area. The territory of Slovenia is characterised by the fact that half of the country consists of karst. In parts of it, surface drainage in the form of

various watercourses is poorly developed and subsurface runoff is very predominant in these areas, which is why the area is characterised by very large karst springs with an average discharge of 5 to 10 m³/s. In the rest of the country, the river network is also strongly influenced by geological conditions, with major rivers flowing along strong regional faults towards NW-SE. The true dendritic network, characteristic of typical river systems, is developed in Slovenia only in the central part on relatively poorly permeable clastic rocks and partly in the NE part of Slovenia in the area of Neogene sediments. The most important rivers are: the Sava, which is also the longest Slovenian river, with an average flow of 272 m³/s at the Croatian border, and the Soča in the west, with an average flow of 90 m³/s at the Italian border. Two important rivers originating in Austria cross only Slovenian territory, the Drava with an average flow of 284 m³/s from Slovenia and the Mura with an average flow of 155 m³/s.

Groundwater is an important aspect of the hydrology in Slovenia. Aquifers are found almost on the entire territory of the country. The aforementioned carbonate karst area, which covers almost 50% of the country, consists of karst aquifers that are highly vulnerable. Unconfined aquifers in Quaternary alluvial sediments make up a significant portion of the state, accounting for about a quarter of the total area. These are aquifers with high storage capacity and yield, in which large pumping stations have been built for the drinking water supply of most of the larger cities (Ljubljana, Maribor, Celje). The rest of the area consists of smaller aquifers with limited yield, but which represent an important local source of drinking water for smaller settlements. Due to the hydrogeology, groundwater is almost the only source of drinking water in the country and accounts for over 90% of the total water flowing from the taps. Domestic water consumption ranges from 130 to 14 l/person/day. Groundwater is also an important source for food and other industries.

Despite the relatively high availability of water, Slovenia faces a number of challenges in water management and governance. This led to the July 2021 water referendum to decide on amendments to the Water Act, which were rejected in their entirety by the referendum. There are also many unresolved issues in the protection of water resources in large urban areas. In the August central Slovenia experienced severe floods.

L 3: THE EVOLUTION AND CHARACTERISTICS OF KARST AQUIFERS

Franci Gabrovšek, Karst Research Institute SRC SASA, Slovenia

Karst aquifers are characterised by their intricate networks of solution conduits, which exert a significant influence on mass and heat transport within karst massifs. To understand these aquifers, it is essential to look at the formation of these conduit systems, a process known as speleogenesis, in originally porous-fractured aquifers. Our understanding of these processes has evolved from rudimentary conceptual models to sophisticated numerical simulations that replicate the evolution of conduit networks by applying equations of fluid dynamics, chemical kinetics and transport. These models have revealed numerous processes and mechanisms responsible for the specific geometry of conduit networks.

The basic building block of speleogenesis is the evolution of a single fracture into a mature conduit, which is governed by a feedback loop between flow rate and dissolution rate. Eventually, this feedback culminates in a sudden increase in both flow rate and dissolution rate, a phenomenon known as "breakthrough". Within a network of such fractures, multiple pathways compete for dominance in connecting inputs and outputs. Usually, a dominant pathway emerges, characterised by optimal geochemical and hydraulic conditions, which suppresses the growth of competing channels. After its breakthrough, networks continue to expand through processes of bypassing and integration, with their development constrained by the recharge. The evolution of vadose network is even harder to predict and model; it depends on the initial (vertical) position of the conduits and on the entrenchment rate of the evolving channels. However, the latter stages can also be affected by sediment transport and accumulation, as well as mechanical erosion. Speleogenetic models also provide valuable insights into the vertical evolution of karst massifs, where increasing permeability causes the water table towards the erosional base.

To understand or evaluate the structure of aquifers and groundwater behaviour in natural environments such as the Dinaric karst, a comprehensive view of the underlying mechanisms revealed by modelling is essential. However, we need to take into account the constantly changing boundary conditions and the complex structural changes caused by active tectonic forces. In such a dynamic environment, predicting the location of channels and the spatial distribution of flow is at least challenging, if not impossible.

Integrating continuous monitoring of groundwater level, temperature and specific electrical conductivity with hydraulic models in water caves and springs allows us to gain insights into the structure of the aquifer and relate them to the dynamics of the observed groundwater flow. The extreme heterogeneity of these aquifers leads to significant fluctuations in groundwater levels during flood events. Our research shows that abrupt changes in flow cross-sections or breakdowns can significantly affect regional flow dynamics and even the distribution of flow to springs.

By monitoring temperature and specific electrical conductivity, we can assess flow directions and velocities within the aquifer. These observations have been carried out

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in various Dinaric systems, including the Reka-Timavo system under Kras/Carso plateau and the Ljubljana catchment. They have provided a wealth of new knowledge about flow dynamics during flood events, facilitated the quantification of flooding in poljes and unravelled the distribution of flow between major regional springs.

L 4: IS THE RECHARGE OF KARST AQUIFERS INFLUENCED BY LARGE-SCALE FOREST DISTURBANCES?

Nataša Ravbar^{1, 2, *}, Urša Vilhar³, Mitja Ferlan³, Janez Kermavnar³, Blaž Kogovšek^{1, 2}, Erika Kozamernik³, Lado Kutnar³, Aleksander Marinšek³, Cyril Mayaud^{1, 2}, Metka Petrič^{1, 2}, David Štefanič³, Daniel Žlindra³

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Worldwide, karst aquifers cover about 15% of the land surface, of which one third is forested. These areas are most common in tropical and subtropical climates, but even in some temperate countries the proportion of forests underlain by karst can be quite high. An example is Slovenia, where almost half of the country territory extends over karstifiable rocks, and 70% of karst areas is covered by forest. These areas provide a variety of ecosystem services, such as regional water budgets and freshwater supply, and host a rich and unique biodiversity with high floristic and ecological species. Given the predicted increase in extreme weather events, more frequent large-scale forest disturbances are expected. Forest damage due to drought, ice storms, wildfires, windthrow, pest and disease outbreaks, etc. can have severe consequences for the vegetation. In our study, we were interested in the extent to which large-scale forest disturbances affect the water balance and thus the aquifer recharge by altering evapotranspiration and other processes. The study focused on a karst spring catchment located in SW Slovenia, almost 70% of which is covered by forest. The area was severely damaged by ice storm, bark beetle infestation and windthrow between 2014 and 2018. The study is based on continuous monitoring of meteorological and hydrogeological parameters throughout the aquifer, which includes the atmosphere – vegetation – soil – unsaturated – saturated aquifer zones, as well as data time series and statistical analyses, numerical modelling and a water balance assessment. Preliminary results show that karst is characterized by rapid infiltration and high recharge rates. Due to reduced canopy interception of precipitation and reduced evapotranspiration, groundwater recharge is higher during vegetation dormancy and when the soil and the unsaturated zone are already saturated with water. In addition, removal of forest vegetation by salvage logging resulted in creation of large canopy gaps, where groundwater recharge is higher compared to remaining forest stands. Overall, this study shows that vegetation cover has a significant influence on how karst aquifers are recharged, and the impact of large-scale forest disturbance on karst accelerates infiltration into the subsurface. Accordingly, the results are crucial for the development of appropriate water and forest management and climate change adaptation policies.

L 5: MODELING KARSTIC AQUIFERS USING NETWORK THEORY

Bojan Mohar, FMF, University of Ljubljana

Between 20 to 25 percent of World population depends on water from karstic aquifers. One particular specialty about karst is that the exact structure of karstic waterways is underground and thus hidden from our observations. This makes it difficult when trying to predict what will happen under unknown conditions like flooding, droughts, or unexpected pollution of karstic water.

A diverse group of scientists from Slovenia, Switzerland, France and Spain started working through an ERC Synergy project¹ with the goal to provide fundamental models for hydrology and hydrogeology in karst. Along with established hydrogeology theory, they intend to include novel approaches that will enable better understanding of karst hydrology.

The speaker will describe some of the main goals and approaches. In particular, he will try to envision the use of modern network and graph theory in providing fundamentals for this challenge.

This talk is a joint work with Marco Dentz (CSIC, Spain), Benoit Noetinger (IFPEN, France), Philippe Renard (University of Neuchatel, Switzerland), and Franci Gabrovšek (Karst Research Institute, Slovenia).

¹Funded in part by the European Union (ERC, KARST, project number 101071836).

L 6: KARST HYDROGEOLOGY OF MONTENEGRO

Milan M. Radulović, Committee for Geology and Geography, Montenegrin Academy of Sciences and Arts; Faculty of Civil Engineering, University of Montenegro

Montenegro is widely known as the country of karst. Over 60% of its territory is built of carbonate rocks. Limestones and dolomites in Montenegro are characterized by a high degree of karstification, which further affects a high infiltration rate and rapid groundwater flow.

These characteristics of karst terrains create paradoxical situations. There are areas with an extremely large amount of precipitation but without any river or stream on the surface. In the hinterland of Boka Bay, the mean annual precipitation is around 5000 mm, and the river network is completely absent. All water circulation takes place underground, and the discharge occurs mainly along the sea coast via strong terrestrial and submarine springs.

The karst aquifer is the primary source of water in Montenegro. About 80% of the water supply system depends on groundwater from the karst. Karst sources generally have a sufficient amount of water, but on the other hand, these water reserves are very sensitive to pollution from the surface.

Looking at the average specific runoff, which is about 43 l/s/km², it could be concluded that Montenegro is extremely rich in water. However, due to the highly pronounced temporal and spatial unevenness in the distribution of water resources, many areas suffer from water scarcity in the dry period. About 30% of Montenegro can be considered a desert in terms of the availability of water resources. Such areas are high karst plateaus from which it is impossible to reach the groundwater level with reasonably deep wells.

In any case, almost all urban areas in Montenegro still have sufficient quantities of water released from the karst aquifer. Probably, the biggest challenge in the future will be the protection of this sensitive resource.

Keywords

Karst, aquifer, water supply, water availability, Montenegro

L 7: SOURCE APPORTIONMENT AND FATE OF METALS IN RIVER ECOSYSTEMS DUE TO ANTHROPOGENIC AND CLIMATE CHANGE FORCING

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The use of isotopic metal signatures is a powerful resource determination tool in river ecosystems, facilitating a thorough examination of metal fates under the dual influence of anthropogenic activities and climate change forcing. Rivers are key media for the transport of metals within the Earth's hydrological cycle, affecting aquatic and terrestrial environments. Using a comprehensive approach that includes environmental monitoring, geochemical analysis and advanced isotopic techniques, we distinguish the places of origin and pathways of metals in rivers, especially in legacy sites due remaining due to human activities, such as mining, industrial processes, agriculture and urbanization, waste disposal, etc.. At the same time, we examine the effects of climate change, which include shifts in precipitation patterns, temperature fluctuations, and hydrologic dynamics, on metal transport and fate in river ecosystems.

Case study from Slovenia (Soča river catchment) provide valuable insights into the complex interplay between anthropogenic pressures and climate change drivers in shaping the fate of metals in river environments. Such insights are critical for informed environmental management and policymaking, with implications for water quality conservation, ecosystem sustainability, and human well-being. The use of isotopic metal signatures, as demonstrated in this study, increases our ability to unravel the complex web of factors influencing metal dynamics in rivers, thereby advancing our knowledge of sustainable resource management and effective pollution reduction strategies.

**L 8: ADVANCED TECHNOLOGIES FOR THE WASTE WATER TREATMENT TO
PROTECT THE LARGEST NATURAL GROUNDWATER RESERVOIR IN
CENTRAL EUROPE – RYE ISLAND**

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The groundwater reserves of the Rye Island (Žitný ostrov), a river island of the Danube, Small Danube and Váh rivers, represent a significant strategic raw material for Slovakia and their protection is also a matter of national security. The usable drinking water capacity of the Rye Island could supply more than 16 million inhabitants at the current average consumption. Rye Island is threatened by progressing chemical pollution, mainly from production waste disposal site from the former J. Dimitrov's Chemical Plant (CHZJD), but also from other industrial activities in the capital Bratislava. The CHZJD landfill represents an area where approximately 120.000 m³ of waste from the chemical industry is buried beneath the surface. After the Gabčíkovo Dam on the Danube was commissioned in 1992, the groundwater level began to rise, causing it to reach the chemical waste landfill ground as early as 1996. At the point of contact, pollutants are leached and thus enter the groundwater. Hazardous substances flow at a rate of 300-500 m/year into the densely populated, agricultural and water-management area of Rye Island.

The Slovak Academy of Sciences with partners focus our research to improve the condition of the area by searching for suitable decontamination methods and their pilot testing. Attention was focused mainly on the elimination of organic pollution through biological and physico-chemical degradation processes. The chemical composition of the contamination is diversified and can be classified into several main groups such as chlorinated polycyclic aromatic hydrocarbons, phenolic compounds, rubber chemicals based mainly on benzothiazole, etc. Accompanying contaminants of inorganic nature such as heavy and semi-metals (e.g. arsenic, lead, copper, chromium, cadmium) are also taken into account. The proposed technology will utilize two basic principles of contaminant removal from groundwater, such as separation processes, in which the contaminant is separated from the matrix (aqueous solution) without significant chemical modification, and destructive processes, in which the organic matter in the matrix is decomposed into inorganic products. Due to the character of the contamination, the electrochemical oxidation will be used as the principal method. The process is suitable for the treatment of waters containing poorly degradable, persistent organic substances or highly toxic substances. It is a method that belongs to the group of so-called 'Advanced Oxidation Processes' (AOP). This technology can be described as zero-waste, with no waste by-products (sludge). The main advantage of this technology is that no chemicals are used. In addition to the water treatment effect, the contaminants are destroyed on-site. The technology is almost waste-free in terms of the elimination of organic

substances, the carbonaceous components are transformed in the final stage into CO₂ and inorganic products without the formation of hazardous residues.

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References:

KUPKA, Daniel - KUBINEC, R. - JÁGER, Dávid - BÁRTOVÁ, Zuzana - JENČÁROVÁ, Jana - MAČINGOVÁ, Eva - VÁCLAVÍKOVÁ, Miroslava - BLAŠKO, J. - FILO, Július - GALBAVÁ, Paulína - SZABÓVÁ, Ž. Partial final report on the state of groundwater pollution from the environmental burden Bratislava - Vrakuňa - Vrakunská cesta, landfill CHZJD and surrounding area: Final report of the research task, r. 2017 for BSK within the project: Joint project of BSK, SAS and PriF UK for research of possibilities of decontamination of environmental burden Bratislava Vrakuňa - Vrakunská cesta-landfill CHJD (in Slovak). 103 p.

**L 9: EMERGING MICROPOLLUTANTS IN WASTEWATERS: REMOVAL TRENDS
AND PERSPECTIVES**

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There is no balance between anthropogenic pressures and surface waters selfpurification capabilities, even though more than 90% of urban waste water across EU is thought to be collected and treated. Therefore, there is a growing commitment to understand and manage pollution with persistent organic micropollutants (pharmaceuticals, personal care products, industrial chemicals, aditives, Etc.). Micropollutants pose a serious problem to environmental sustainability and remediation, due to their widespread use and applications in everyday life. This group of chemicals is diverse but with common toxic and harmful properties. Their concentration in the environment is often very low; however, due to their recalcitrant nature, they are persistent in air, water, and soil. It is difficult to remove them from wastewaters and drinking water by conventional treatment methods. As a result, new methods are being developed to improve and upgrade conventional treatment systems. Advanced oxidation processes (AOPs) are widely accepted processes for degradation of resistant micropollutants or at least to enhance their biodegradability. Many combinations of homo- and heterogenic AOPs exists, which include additions of various solid or dissolved catalysts and/or electro-, photo- or sonochemical treatment. AOPs are continuously being developed in the direction of 'low-cost, high-tech, chemical-free' ideal. One such opportunity has been electrochemical oxidation, being in focus recently. The aim of this presentation is to discuss current trends aimed at solving problems in the research and application of such processes in the removal of micropollutants from wastewater, thus preventing leakage of harmful substances into surface water, soil, and groundwater and facilitating the reuse of wastewater.

Keywords: advanced oxidation processes, environmental impact, micropollutants, technologies, wastewaters.

L 10: SEAFOOD CONTAMINATION WITH MICROPLASTIC: ANALYTICALLY CHALLENGED GLOBAL PROBLEM

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Plastic particles have been ubiquitously detected in a broad range of shapes, chemical compositions, sizes and concentrations in the environments of marine water, freshwater, agroecosystems, atmosphere, food, drinking water and biota. Estimates suggest 5.25 trillion plastic particles currently circulate in ocean surface waters. A dramatical increase in plastic use and plastic waste has peaked also because of the COVID19 pandemic during spring 2020 further stressing issues of environmental safety. Plastic is persistent in the environment because it is manufactured to be durable. Plastic polymers can be slowly degraded by microorganisms, heat, oxidation, light, or hydrolysis. The degradation of plastic will eventually result in formation of microparticles commonly known as microplastics (MPs), currently defined as plastic materials with various morphologies in the range of 0.1–5,000 μm . Unfortunately, solid data on the prevalence of MPs in the environment are still limited due to the analytical and technical challenges of extraction, characterization, and quantification from environmental matrices.

The accumulation of microplastics in marine organisms is an emerging concern. Given the small size and pervasive nature of MP, ingestion by several marine species (mollusks, crustaceans, fish, and echinoderms) has been observed. Once ingested, MP are distributed and accumulate in various organs such as gills, gut, liver, kidneys. Due to trophic transfer, the safety of seafood is under investigation in view of the potential negative effects of microplastics on human health. While many studies on marine ecotoxicology and the occurrence of MPs in fish and shellfish exist, ranges of MPs found in marine species shows huge diversity and heterogeneity due to the lack of standardized analytical solutions for MPs characterization and quantification. We have observed that both digestion efficiency of the biological tissue and sample preparation significantly may affect MPs quantification (occurrence reported) and sources of external contamination of the samples are numo. We have collected and comparatively analyzed marine species (Crustaceas and Molluscs) from different markets in Europe and Asia using an optimized digestion protocol and full coverage of the samples by microFTIR analysis. MPs contamination in seafood samples from point-of-sale shrimps, clams and mussels has consistently been found to be very low in all tested species and regions.

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L 11: THE BIODIVERSITY IN THE BULGARIAN SECTOR OF THE DANUBE RIVER – STATUS, MAIN THREATS, AND CHALLENGES

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The Danube River is often called Europe's backbone of biodiversity. The natural ecosystems along the Bulgarian part of the river are also considered extremely important as hot spots of natural and semi-natural biodiversity and priority conservation areas. We present a brief survey on the diversity of life in the Bulgarian sector of the river and the main challenges related to its conservation.

Recent studies have shown that the Bulgarian sector of the Danube River and adjacent territories host more than 3000 taxa of algae, 200 species of macromycetes, more than 600 species of vascular plants, and several thousands of animal species, most numerous being invertebrates and, particularly, insects. There are 73 species of fish, some of them of high conservation concern, including the six sturgeon species. Mammals are more than 40 species and many of them are rare and protected.

The region is characterised by a great diversity of riverine habitats and habitats directly influenced by the river's proximity. More than ten habitats are of primary importance for the EU and are listed in Directive 92/43/EEC.

The rich biodiversity along the Danube River in Bulgaria is protected in different categories of protected territories. There are two nature parks, six nature and maintained reserves, and numerous protected sites. Natura 2000 network is represented by 25 zones declared according to the Habitats Directive and 11 zones declared according to the Birds Directive.

However, the rich biodiversity in the region has faced serious threats and issues over the years. Still, in the first half of the 20th century, many wetlands near the Danube River were drained and converted into agricultural land or fast-growing poplar plantations, drastically losing biodiversity. The process of its decline continued in the second half of the 20th century and is still underway. Environmental pollution, including transboundary ones, biological invasions, change in the water regime, improper management and use of natural resources, and other negative factors of local importance were joined by a global factor – climate change. All these challenges can hardly be addressed at a national level. Therefore, the international cooperation of the Danubian countries is of crucial importance for mitigating and reducing the effect of the negative factors and for making a step forward in the conservation of this fragile and extremely valuable ecosystem.

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L 12: INFORMATION TO THE AUTHORITIES AND LOCAL PEOPLE ALONG THE RIVER DANUBE CONCERNING THE FLOOD REGIME OF RIVERS AT THE BASIN – An empirical evaluation

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The authorities and local people should benefit from sharing and disseminating information with regard to the hydrological regime and water quality of rivers at the Danube basin. The first comprehensive hydrology of the river Danube was published in 1988 [1]. Based on many decades of cooperation among the national Committees of the Intergovernmental Hydrologic Program and – IHP UNESCO and the joint work of numerous national experts, a monograph on historical floods at the river Danube catchment between the years 1001 and 2001 was published in 2019 [2]. The work on this study required a substantial amount of time and enormous efforts were made in order to collect the majority of available data that had to be processed and analysed afterwards. Connecting prehistoric and modern times, extensive human, cultural, educational and other resources and values have been preserved and sometimes hidden in many cities and towns located all along the river Danube [3]. Dealing with the historical floods and hidden values in a considerable number of urban societies along the Danube, two recently launched publications represent only a small part of the great treasure contained in the whole basin of approximately 800,000 km².

From the ancient times, habitats, settlements such as the archeological site of Vinca on the Danube and numerous locations, which were established many millennia before the Common Era, had to be saved and preserved from high waters and floods. In addition, a vast number of writers throughout the past centuries who had shown an interest in the aforementioned issues, undertook a wide-ranging investigation and research of these phenomena. In conclusion, people living on the Danube, in each and every city or village, should develop awareness of potential threats and consequences for humans and their cultural and historic treasures, including the results on the water quality of the river Danube [4].

Keywords: *Danube; Hydrology; Floods; Humans; Urban; Rural; Values; Cultural; Historical; Quality.*

[1] Stancuk, A., Jovanovic, S. et al. (Eds.) *Hydrology of the River Danube*, Publishing House Priroda, Bratislava, 1988.

[2] Pekarova, P., Miklanek, P. (Eds.) *Flood regime of rivers in the Danube River basin*. Follow up volume IX of the Regional Co-operation of the Danube Countries in the IHP UNESCO, IH SAS, Bratislava, 215 p. + 527 p. app., DOI: 10.31577/2019.9788089139460.

[3] Djukic, A., Kadar, B., Stan, A., Antonic, B. (Eds) *ATLAS of Hidden Urban Values along the Danube*, Interreg – Danube Transnational Programme – DANURB+, 2022 University of Belgrade Faculty of Architecture, ISBN 978-86-7924-320-1.

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[4] Liška, I., Wagner, F., Sengl, M., Deutsch, K., Slobodník, J., Punović, M.(Eds.):
Joint Danube Survey 4 Scientific Report - A Shared analysis of the Danube river,
ICPDR, Vienna, 2019.

**L 13: DISTURBED PEATLANDS RESTORATION EXPERIENCE IN
BELARUS**

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Mires and wetlands are key habitats for biodiversity conservation and the most important fresh water accumulators in the Republic of Belarus. Previously, before large-scale drainage reclamation, the mires area in Belarus was 2,560,500.0 hectares, or 12.5% of the country's territory. Currently, about 863,000.0 hectares of mires (33.7% of the original area) still retain in a close to natural state, 1,397,500.0 hectares of mires drained for agriculture and forestry use, as well as about 300,000 hectares – for peat extraction. By now, more than 7 billion m³ of fresh water reserves accumulated in the remaining mire ecosystems, which provide sustainable water supply for rivers and lakes in the country.

For now, as a result of peat extraction and mire drainage for agriculture and forestry, significant areas of disturbed peatlands formed, which further economically efficient use is impractical for various reasons. These areas include degraded peat soils previously used in agriculture (258,800.0 hectares), and inefficiently used peat deposits retired from industrial exploitation (143,300.0 hectares).

Disturbed peatlands cause significant ecological damage to the environment, primarily due to carbon emissions, as well as large-scale peat fires. According to MCD64A1 data, 10,500.0 natural fires recorded in the period 2001–2020 on an area of 888,9000.0 hectares (4.3% of the Belarus territory). Fires in the southern country part are particular danger; in the 20th century second half, the largest drainage reclamation took place here, and in addition, radioactive contamination after the Chernobyl nuclear power plant accident localized here.

Under the current conditions, the most expedient, and sometimes the last way for the disturbed bogs sustainable use is their rebogging. Since 2006, 40 project areas restored in Belarus with about 70,000,0 hectares total area (13.6% disturbed peatlands area). The main task in secondary bogging is to raise the water level in the restored area most part to the surface level. This achieved by cascade overlapping channels in a accordance with the surface slope. In some cases, re-swamping carried out with the restoration of black alder (*Alnus glutinosa*) forests.

As part of the developed monitoring system for the restored peatlands dynamics, a significant peat fires reduction, a greenhouse gas emissions decrease (11,100,000 tons of CO₂-eq over a period of 20 years), a hydrological regime restoration, as well as bog flora and fauna restoration established.

The National Plan of the Disturbed Peatlands Restoration (until 2040) includes 214 objects with a total area of 298,4000.0 hectares. As a result of rebogging, the following environmental effects are predicted: greenhouse gas emissions reduction (by 633,700 tons of CO₂-eq. year⁻¹), fresh water conservation (55,065,000 m³), rehabilitation of a high fire hazard areas (73,500 hectares), habitats important for the biodiversity conservation restoration (on an area of 8.8 thousand hectares).

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Belarus developed and entered into force the Law of the Peatlands Protection and Use, which regulates the procedure and rules for the disturbed peatlands ecological rehabilitation.

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