Proceedings of the 5th International Symposium of Healthy Rivers and Sustainable Water Resources Management : ECOHYDROLOGY FOR WATER SECURITY

Maciej Zalewski, Jinsong Guo, Pascal Breil

ECOHYDROLOGY
FOR WATER SECURITY

5th International Symposium of Healthy Rivers and Sustainable Water Resources Management

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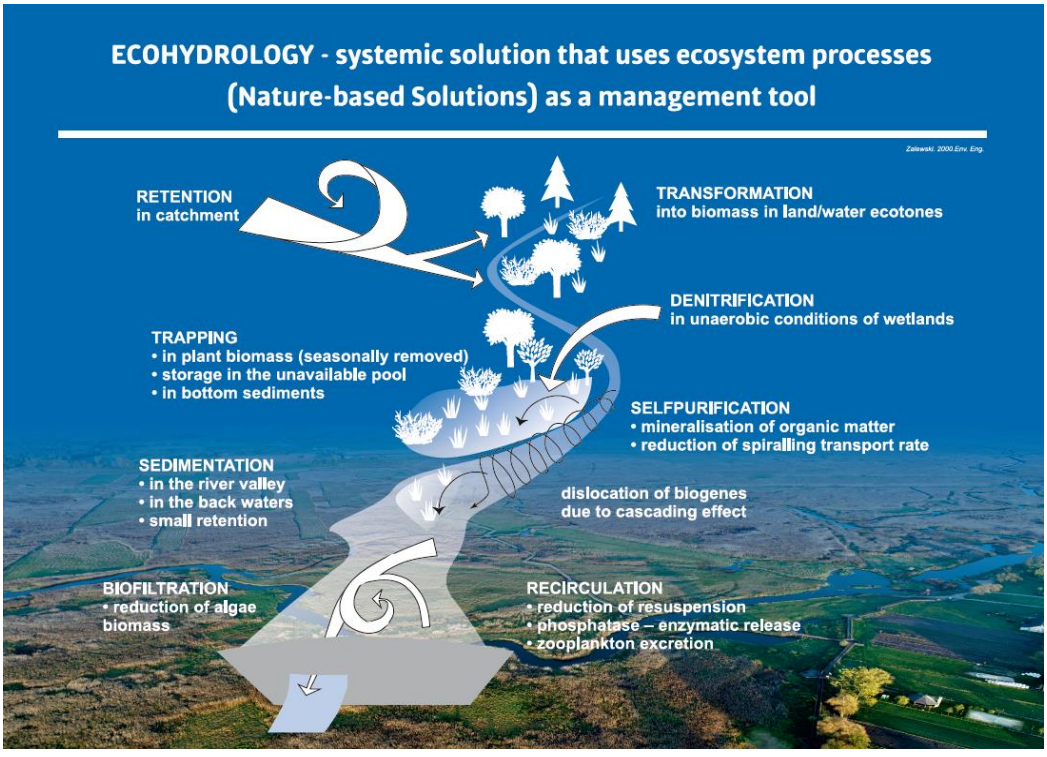

Proceedings of the

5th International Symposium of Healthy Rivers and Sustainable Water Resources Management

ECOHYDROLOGY FOR WATER SECURITY

8-9 June 2022, Warsaw, Poland

Co-chairs

Professor Maciej Zalewski, Director of the European Regional Centre for Ecohydrology of the Polish Academy of Science u/a UNESCO
Professor Jinsong Guo, Chongqing University, China

Organizing Institutions

UNESCO Intergovernmental Hydrological Programme
European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland u/a UNESCO
Polish Academy of Sciences
Chongqing University, China
UNESCO Chair on Ecohydrology and Applied Ecology, University of Lodz, Poland

Hosting Institution

Polish Academy of Sciences
Staszic Palace, Warsaw, Poland

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PROCEEDINGS OF THE 5TH INTERNATIONAL SYMPOSIUM OF HEALTHY RIVERS AND SUSTAINABLE WATER RESOURCES MANAGEMENT

ECOHYDROLOGY FOR WATER SECURITY

European Regional Centre for Ecohydrology of the Polish Academy of Sciences
3 Tylna Str., 90-364 Lodz, Poland

Rationale

Considering the increasing role of water as a key driver of the global, regional and local sustainability, in addition to the role of rivers as most important supplier of renewable water resources, the European Regional Centre for Ecohydrology of the Polish Academy of Sciences under the auspices of UNESCO, in cooperation with the Chingqing University, is organizing, under the theme of "Ecohydrology for Water Security", the 5th International Symposium of Healthy Rivers and Sustainable Water Resources Management.

According to most recent UNESCO documents, there is an urgent need to accelerate the implementation of water-related SDG through water science and education. Considering the above the great potential for acceleration is in the use of ecosystem properties as innovative management tools – Nature Based Solutions (NBS). Ecosystems are natural recirculators and purifying systems which at the global scale regulate and stabilize more than 60% of the hydrological mesocycle. The most important challenge for water management is how to increase water resources quantity and quality by reducing the pressure (impacts) to ecosystems at all scales. The answer is, by using the holistic approach based on the understanding of water-biota interplay ("Dual Regulation"), which can be translated into NBS. Such approach is the merit of ECOHYDROLOGY – an integrative transdisciplinary science providing NBS not only for 1/ reduction of impacts, but also 2/ enhancement of the catchment sustainability potential WBSRCE. The acronym WBSR, means that every water management actions/investments in catchments has to improve four parameters: Water, Biodiversity, Services for society, Resilience to climate and impacts, the implementation of which has to be broadly supported by Culture and Education of water for sustainability, thus the conscious and wise involvement of society through exchange, dissemination, training and awareness, further stimulated by new dimensions of policy and law (WBSR+CE+PL)

The evolution of the Ecohydrology paradigm within UNESCO-IHP since its beginning in 1996, will be the important reference point for the identification of new challenges and development of new emerging ecohydrological nature based methods and systemic solutions in the context of the strategy and priorities of UNESCO-IHP phase IX "Science for a Water Secure World in a Changing Environment" (2022-2029).

The organizers assume that the exchange of ideas will be important not only as inspiration for further development of the transdisciplinary knowledge - Ecohydrological Nature-Based Solutions (EH NBS), but will also enforce international network of cooperation, which should accelerate and adopt the process of development and implementation of WBSR+CE+PL for Integrated Water Resources Management (IWRM).

Co-Chairs of the Symposium:

***Maciej Zalewski**, Professor, Director of the European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO*

Professor Maciej Zalewski is the founder of the Department of Applied Ecology in the Faculty of Biology and Environmental Protection of University of Lodz and the founding director of the European Regional Centre for Ecohydrology of the Polish Academy of Science since the year 2000.

From 1989 he is one of the leading experts in UNESCO in ecohydrology and coordinates research projects there. In the years 1989-1996 he was the leader of a work group within the UNESCO Man and Biosphere (MAB) programme – "Fish and Land-Inland Water Ecotones". He was also the leader of a work group of the European Commission on Fishing EIFAC FAO "Physical Habitat Modification and Freshwater Fisheries". In the years 1996-2006, and from 2010, he is the leader of the Scientific Advisory Committee of UNESCO in the programme "Ecohydrology" (International Hydrological Programme, IHP).

Professor Zalewski is the author of a novel concept of ecohydrology which is the basis for the methodology of "Nature-Based Solutions", that is recently being developed by the United Nations. He is a recognised scientist both in Poland and abroad. In the years 2001-2004 he was a member of the Scientific Board of the UNESCO Regional Bureau on Science in Venice.

For his scientific accomplishments, professor Zalewski has been honoured with numerous prizes, to name a few: the Scientific Award of the Minister of National Education (1979, 1987, 1998), Golden Cross of Merit (1998), the President of Polish Academy of Science Award (2001), the award for the co-author of the best handbook published by the University of Łódź (2004-2005), the Scientific Award of the Prezydent of Łódź (2006) and the Award for Merit to the City of Łódź (2006).

The scientific team of the European Regional Centre for Ecohydrology and the Department of Applied Ecology under the supervision of Professor Zalewski conducts numerous scientific projects both local and international. Among these projects, two were awarded in 2018 by the European Commission as Best LIFE+ in 2018 for project "Ecotones for reducing diffuse pollution" (EKOROB) and Best of the Best LIFE+ 2018 for project "Ecohydrologic rehabilitation of recreational reservoirs "Arturówek" Łódź as a model approach to rehabilitation of urban reservoirs".

In 2020, Professor Zalewski was nominated as an expert by the Committee of the Regions of the European Commission to prepare an opinion on the effectiveness of implementation and identification of new challenges for the Water Framework Directive. The directions of WFD extension in the context of adaptation to climate change, proposed by the professor, were accepted during consultations and unanimously adopted at the meeting of the Committee of the Regions.

***Jinsong Guo**, Professor, Chongqing University*

Prof. Jinsong Guo is a member of expert group on assessment models of greenhouse gas effects in reservoirs (UNESCO / IHA). He is also member of council of several International and domestic academic associations, i.e. International Water Association (IWA), China Marine limnology society lake branch, Special committee on lakes and wetlands of the geographical society of China. He is currently an Associate Editor in Chief of Ecohydrology & Hydrobiology, Editorial Board of Journal of Mountain Science, Journal of Lake Sciences, Resources and Environment in The Yangtze Basin. He has established the algae cell particle size classification method based on flow cytometry, invented a field in-situ experimental device that can dynamically regulate and exchange substances in the environment and preliminarily established the framework of cell ecological stoichiometry model based on structured idea. Prof. Guo has more than 120 publications in peer-reviewed high quality journals (Environmental Science & Technology, Water Research, Journal of Hazardous Materials, Ecohydrology & Hydrobiology, Journal of Cleaner Production, Science of the Total Environment, Chemosphere, Ecological indicator, Ecotoxicology and Environmental Safety, etc. These papers have been cited in Web of Science 1967 times (h=23). Several books have been published according to his research outcomes.

Steering Committee Members, Members of the Board and Keynote Speakers:

Prof. Maciej Zalewski, Director, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO, Poland (Co-Chairman)

Prof. Jinsong Guo, Chongqing University, China (Co-Chairman)

Dr. Marco Albarracin, CEO, Ecohydrological Foundation, Ecuador

Dr. Andrew Allan, Director of the Centre for Water Law, Policy and Science, University of Dundee, UK

Dr. Giuseppe Arduino, University of Algarve, Portugal

Dr. Pascal Breil, IRSTEA, France

Prof. Luis Chicharo, University of Algarve, Portugal

Dr. Muhammad Nazif Bin Daud, Director Humic Tropics Centre, Malaysia

Dr. Stefano Fazi, Water Research Institute-CNR, Italy

Prof. Iwona Jasser, President of the Polish Hydrobiological Society, University of Warsaw, Poland

Prof. Shahbaz Khan, UNESCO Cluster Office in Beijing

Prof. Edyta Kiedrzyńska, European Regional Centre for Ecohydrology of the Polish Academy of Sciences

Dr. Makarius Lalika, University of Morogoro, Tanzania

Prof. Zhe Li, Chinese Academy of Sciences

Prof. Artur Magnuszewski, University of Warsaw, Poland

Prof. Joanna Mankiewicz-Boczek, European Regional Centre for Ecohydrology of the Polish Academy of Sciences

Prof. Eduardo Mario Mendiondo, University of Sao Paulo, Brazil

Prof. Patrick Meire, University of Antwerp, Belgium

Prof. William Mitsch, Everglades Wetland Research Park, USA

Dr. Tadanobu Nakayama, National Institute for Environmental Studies, Japan

Mr. Yohannes Zerihun Negussie, Ministry of Water, Ethiopia

Prof. Krystian Obolewski, Kazimierz Wielki University in Bydgoszcz, Poland

Prof. Tomasz Okruszko, Vice-president of the Warsaw University of Life Sciences, Poland

Prof. Piotr Parasiewicz, S. Sakowicz Inland Fisheries Institute, Olsztyn, Poland

Prof. Artur Radecki-Pawlik, Institute of Structural Mechanics, Cracow University of Technology, Poland

Dr. Elfithri Rahmah, Global Water Partnership, Southeast Asia, Malaysia

Prof. Paweł Rowiński, Vice-President, Polish Academy of Sciences, Poland

Prof. András Szöllősi-Nagy, Department Of Water And Environmental Policy, Faculty Of Water Sciences, National University Of Public Service-Budapest, Hungary

Prof. Ignasius Sutapa, Director of Asia Pacific Centre for Ecohydrology (APCE) – UNESCO, Indonesia

Prof. Jose Galizia Tundisi, International Institute of Ecology, Brazil

Prof. Karl Matthias Wantzen, University of Tours, France

Prof. Eric Wolanski, James Cook University, Australia

Prof. Jun Xia, Chineese Academy of Sciences; Director of the Research Institute for Water Security, Wuhan University, China

Organizing Committee:

Prof. Maciej Zalewski, Head of the Organizing Committee, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO, Poland (Co-Chairman)

Dr. Paweł Jarosiewicz, Symposium Secretary, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO, Poland

Organizing Team:

Dr. Małgorzata Połatyńska, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO, Poland

Aleksandra Chamerska, European Regional Centre for Ecohydrology of the Polish Academy of Sciences u/a UNESCO, Poland

Members of the Students Association for Ecohydrology, UNESCO Chair on Ecohydrology and Applied Ecology, Faculty of Biology and Environmental Protection, University of Lodz, Poland:

Zuzanna Bedlińska, Konrad Budziński, Patrycja Chamczak, Aleksandra Góralczyk, Aleksandra Górecka, Paulina Michalak, Ewa Michalska, Dominika Piwowarska, Dagmara Radziszewska, Jakub Rycerz, Anna Wieczorek

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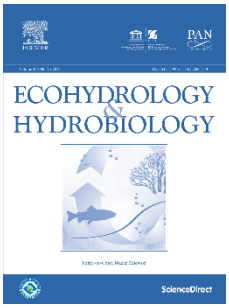

Ecohydrology & Hydrobiology (IF: 3.215), an official journal of European Regional Centre for Ecohydrology of the Polish Academy of Sciences, has been established in the framework of UNESCO International Hydrological Programme in 2001.
As a response to serious degradation of evolutionarily established global water and nutrient cycles and energy flows through ecosystems and an urgent call for sustainability, this journal aims to advance Ecohydrology as the study of the interplay between ecological and hydrological processes from molecular to river basin scales, to develop innovative ecosystem biotechnologies (e.g. dual regulation, phytotechnologies, microbial regulators, etc.) and systemic solutions, and to promote their implementation as an integrative management tool to harmonize societal needs with their enhanced sustainability potential. Hydrobiology understanding coupled with catchment's hydrology and other ecosystem properties, dynamics and functions, and their anthropogenic modifications should be a part of problem-solving sustainability science.
Journal's prime interest are the following sustainability and problem-solving research topics:

- Interactions of water, nutrient and pollutant cycles with biotic components of ecosystems;
- Modeling of ecohydrological processes;
- Translation of transdisciplinary knowledge into decision-support tools;
- Ecosystem biotechnologies and nature-based solutions engaging 'dual regulation' water-biota mechanism, and their integration with engineering infrastructure into system solutions;
- Holistic catchment scale sustainability assessment approaches and management strategies incorporating key ecohydrological components.

Programme of the Symposium

WEDNESDAY 8th JUNE

08:30	**REGISTRATION**
09:30	**OPENING REMARKS AND WELCOME SPEECH**
	Paweł Rowiński, *professor, Vice-President of the Polish Academy of Sciences*
	Maciej Zalewski, *professor ERCE PAN u/a UNESCO, Poland /* **Jinsong Guo**, *professor, Chongqing University, China (as Chairs of the Symposium)*
	Abou Amani, *Director of the Division of Water Sciences and Secretary of the Intergovernmental Hydrological Programme (IHP), UNESCO*
	Monika Niemiec-Butryn, *Director, Department of Water Management and Inland Navigation, Ministry of Infrastructure, Poland*
	Olivier Bouc, *European Partnership "Water4All - Water Security for the Planet", Programme Coordinator*
	Alicja Jagielska-Burduk, *General Secretary,, Polish Committee for UNESCO*
10:30	**SESSION I** **UNESCO SPECIAL SESSION – DEVELOPMENT AND EVOLUTION OF IHP TOWARDS IHP-IX WATER FOR SUSTAINABILITY AND SECURITY** **Session Chairs: prof. Paweł Rowiński, prof. András Szöllősi-Nagy**
10:30	KEYNOTE LECTURE: SUSTAINABLE DEVELOPMENT GOALS – URGENT NEED FOR ACCELERATION **András Szöllősi-Nagy**, *professor, Department of Water and Environmental Policy, Faculty of Water Sciences, National University of Public Service, Budapest, Hungary*
10:45	ECOHYDROLOGY AT UNESCO: AN EVOLUTIONARY PROGRAM FROM DESCRIPTIVE TO SOLUTION-ORIENTED SCIENCE **Giuseppe Arduino**, *UNESCO Chair on Ecohydrology University of Algarve, Portugal*
11:00	ECOHYDROLOGY IN THE INTERGOVERNMENTAL HYDROLOGICAL PROGRAMME IX 2022-2029 **Elfithri Rahmah**, *PhD, Chief of Section Capacity Development and Water Family Coordination (CDW) Division of Water Sciences Intergovernmental Hydrological Programme (IHP) UNESCO*
11:15	ECOHYDROLOGY AND NATURE BASED SOLUTIONS – STATE OF THE ART IN UNESCO ASIA AND PACIFIC REGION (ONLINE) **Shabaz Khan**, *professor, Director UNESCO Office Beijing, China*
11:30	CARBON EMISSIONS: A NEW DIMENSION IN ECOHYDROLOGY (ONLINE) **Zhe Li**, *professor, Chongqing Institute of Freen and Intelligent Technology, Chinese Academy of Sciences, China*

11:45 ECOHYDROLOGY FOR WATER SECURITY IN THE GLOBAL SOUTH: COOPERATIVE SOLUTIONS FOR TRANSBOUNDARY CHALLENGES (ONLINE)
Mario Mendiondo, *professor, Water Resources Engineering, Sao Carlos School of Engineering, University of Sao Paulo, Brazil*

12:00 **COFFEE BREAK & POSTER SESSION**

12:15 **II SESSION**
ECOHYDROLOGY – ENHANCEMENT OF CATCHMENT SUSTAINABILITY POTENTIAL (WBSRCE: WATER, BIODIVERSITY, ECOLOGICAL SERVICES, RESILIENCE, CULTURE AND EDUCATION).
Session Chairs: prof. Edyta Kiedrzyńska, dr. Elfithri Rahmah

12:15 KEYNOTE LECTURE: WATER-ECOSYSTEM-FOOD-ENERGY NEXUS
Karl Matthias Wantzen, *professor, UNESCO Chair River Culture – CNRS UMRS Citers (Tours) and Live (Strasbourg), France*

12:30 ECOHYDROLOGICAL APPROACH TO WATER RESOURCES HEALTH ANALYSIS AND ANTHROPOGENIC POLLUTION FROM GLOBAL TO RIVER CATCHMENT SCALE
Edyta Kiedrzyńska, *professor, European Regional Centre for Ecohydrology of The Polish Academy of Sciences, Poland*

12:45 PRINCIPLES OF DEVELOPMENT OF A POLISH-UKRAINIAN TRANSBOUNDARY GROUNDWATER MONITORING NETWORK
Tatiana Solovey, *professor, Polish Geological Institute – National Research Institute, Warsaw, Poland*

13:00 ECOHYDROLOGICAL NATURE BASED SOLUTION FOR HARMONIZATION OF LAKE TANA SHORE ECOSYSTEM AND SOCIETAL NEEDS, BAHIR DAR, ETHIOPIA (ONLINE)
Yohannes Zerihun Negussie, *PhD, African Regional Center for Ecohydrology U/A of UNESCO, Ethiopia*

13:15 THEORY AND TECHNOLOGY APPLICATION OF NATURAL AND ARTIFICIAL COORDINATED REGULATION OF WATERSHED ECOLOGICAL FUNCTIONS (ONLINE)
Denghua Yan, *professor, China Institute of Water Resources and Hydropower Research, China*

13:30 NATURE-BASED SOLUTIONS AND ECOLOGICAL ENGINEERING: OUR BEST HOPES FOR RESTORING LAKES, RIVERS, AND ESTUARIES AND PROTECTING HUMAN HEALTH (ONLINE)
William Mitsch, *professor, The Ohio State University / Everglades Wetland Research park, and* **Juliet C. Sproul** *Chair for Southwest Florida Habitat Restoration, Florida Gulf Coast University, USA*

13.45 **LUNCH**

14.30 **III SESSION**
POLICY AND LAW FOR ACCELERATION OF SUSTAINABLE DEVELOPMENT GOALS AND GREEN DEAL
Session chairs: Andrew Allan, Olivier Bouc

14:30	KEYNOTE LECTURE: LEGAL FRAMEWORK FOR ADAPTATION WATER MANAGEMENT TO GLOBAL CHANGES **Andrew Allan**, *University of Dundee, Scotland*
14:45	GREEN DEAL - NEED FOR NEW LEGAL FRAMEWORK **Maciej Riemer**, *Department Director for Ecology and Climate, City of Lodz, Poland*
15:00	PHILOSOPHY OF LAW – FRAMEWORK FOR BLUE-GREEN POLICY IMPLEMENTATION **Bartosz Wojciechowski**, *professor, Faculty of Law and Administration University of Lodz, Poland*
15:15	LAW AND CHALLENGES OF SUSTAINABILITY **Monika Zalewska**, *PhD, Faculty of Law and Administration University of Lodz, Poland*
15:30	GREEN DEAL AND INCREASING GLOBAL DEMAND FOR FOOD, CREATING CLIMATE RESILIENT AGRICULTURAL LANDSCAPE **Wojciech Frątczak**, *Director of the Department of Agriculture and Rural Development Programs, Marshal's Office of the Lodz Voivodeship, Poland*
15:45	WATER FRAMEWORK DIRECTIVE IMPLEMENTATION IN POLAND - CHALLENGES AND WAY FORWARD **Piotr Korzeniowski**, *professor, Faculty of Law and Administration University of Lodz, Poland*
19:00	**CONFERENCE DINNER**

THURSDAY 9th JUNE

8:30	**REGISTRATION**	
Session IV + V parrarel	**RIVER SYSTEM PROCESSES, FROM MOLECULAR TO CATCHMENT SCALE, IN THE FACE OF CLIMATE CHANGE** **Session chairs: prof. Iwona Wagner, prof. Artur Magnuszewski**	**ENVIRONMENTAL BEHAVIOR AND HEALTH EFFECTS OF POLLUTANTS IN RIVER ECOSYSTEMS** **Session chairs: prof. Joanna Mankiewicz-Boczek, prof. Iwona Jasser**
9:00	KEYNOTE LECTURE: VISTULA RIVER SEDIMENTATION TRANSFER DYNAMICS IN THE PERSPECTIVE OF RIVER VALLEY EVOLUTION **Artur Magnuszewski**, *professor, Warsaw University, Poland*	KEYNOTE LECTURE: TEMPORAL INTERACTION BETWEEN PELAGIC BACTERIA AND MICROCYSTIN-PRODUCING CYANOBACTERIA AS IMPORTANT ASPECT IN WATER QUALITY ASSESSMENT **Joanna Mankiewicz-Boczek**, *professor, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*
9:15	NATURE-BASED SOLUTIONS – CHANCES AND CONSTRAINS FROM RIVER BASIN PERSPECTIVE	ARE CYANOBACTERIA A REAL THREAT TO SURFACE WATERS IN COLD, ARID ENVIRONMENT?

	Tomasz Okruszko, *professor, Vice-president of the Warsaw University of Life Science, Poland*	**Iwona Jasser**, *professor, Institute of Environmental Biology, Warsaw University, Poland*
9:30	ASSESSMENT OF HABITAT AROUND BARRIERS WITH HABITAT MODEL MESOHABSIM OR SELECTION OF MANAGEMENT ALTERNATIVES **Piotr Parasiewicz**, *professor, Head of River Fisheries Department, S. Sakowicz Inland Fisheries Institute, Poland*	ROAD SALT (SALINIZATION) – A YEAR-ROUND THREAT TO AQUATIC ECOSYSTEMS **Sebastian Szklarek**, *PhD, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*
9:45	A NOVEL METHODOLOGY FOR RAPID IN SITU ASSESSMENT OF THE HIGH-RESOLUTION SPATIAL AND TEMPORAL DISTRIBUTION OF CYANOBACTERIAL BLOOMS USING FISHERY ECHOSOUNDER **Malgorzata Godlewska**, *professor, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*	MICROBIAL AND CHEMICAL QUALITY ASSESSMENT OF THE SMALL RIVERS ENTERING THE BALTIC SEA **Emilia Bączkowska**, *Gdansk University of Technology, Poland*
10:00	ELUCIDATING THE BIOTECHNOLOGICAL APPLICATION OF NITROGEN-TRANSFORMING BACTERIA FOR THE FUTURE IMPROVEMENT OF NATURE-BASED SOLUTIONS **Arnoldo Font-Najera,** *European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*	SIMULATION OF EMERGING POLLUTANTS IN TYPICAL RIVERS AND LAKES IN THE GREATER BAY AREA, CHINA (ONLINE) **Yanpeng Cai**, *professor, Guangdong University of Technology, Associate Editor of Ecological Engineering, China*
10:15	MOLECULAR APPROACH TO INFER SELF-PURIFICATION POTENTIALITIES OF RIVER SYSTEM (ONLINE) **Stefano Fazi**, *PhD, Water Research Institute, National Research Council of Italy (IRSA-CNR), Italy*	EFFECTS-BASED TECHNIQUES FOR RIVER HEALTH ASSESSMENT AND KEY TOXICANTS IDENTIFICATION (ONLINE) **Ying Shao**, *PhD, College of Environment and Ecology, Chongqing University, China*
10:30	IMPACT OF ANTHROPOGENIC DISTURBANCES ON WATER AVAILABILITY IN MONGOLIAN URBAN AND MINING HUBS TOWARDS EFFECTIVE UTILIZATION OF WATER RESOURCES (ONLINE) **Tadanobu Nakayama**, *professor,*	UNEXPECTED NITROGEN FLOW AND WATER QUALITY CHANGE DUE TO VARYING ATMOSPHERIC DEPOSITION (ONLINE) **Lei Chen**, *professor, School of Environment, Beijing Normal University, China*

	National Institute for Environmental Studies (NIES), Tsukuba, Japan	
10:45	THE USE OF ECOHYDROLOGY TO SOLVE THE THREAT FROM CLIMATE CHANGE AND DAMS TO THE BURDEKIN RIVER DELTA AND COAST, GREAT BARRIER REEF, AUSTRALIA (ONLINE) **Eric Wolanski**, *professor, College of Science and Engineering, James Cook University, Australia*	ASSESSING WATER QUALITY OF PONDS IN LATERITIC TRACTS OF EASTERN INDIA ACROSS A RURAL-URBAN GRADATION USING MULTIVARIATE APPROACH (ONLINE) **Priyanka Halder Mallick**, *Department of Zoology, Vidyasagar University, India*
11:00	THE ROLE OF RIVER HEALTH ASSESSMENT IN WATER RESOURCES MANAGEMENT: A CASE STUDY OF RUVU AND SIMIYU RIVER CATCHMENTS IN TANZANIA (ONLINE) **Rosemary Masikini**, *Lake Victoria Basin Water Board, Ministry of Water, Tanzania*	ALGAL DIVERSITY IN THE CASCADE RESERVOIRS FROM THE UPPER YANGTZE RIVER (ONLINE) **Yonghong Bi**, *professor, Institute of Hydrobiology (IHB), Chinese Academy of Sciences, China*
11:15	SUSTAINABLE MANAGEMENT OF NATIONAL PARKS REQUIRES INCLUSION OF RIVER CATCHMENTS UPSTREAM (ONLINE) **Emilian Kihwele**, *PhD, Tanzania National Parks, Arusha, Tanzania*	ASSESSMENT OF HYDROLOGICAL BARRIERS EFFECT IN RIVER BENTHIC FAUNA COUPLED WITH eDNA METABARCODING MONITORING (ONLINE) **C. Ntislidou**, *Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Thessaloniki, Greece*
11:30	IMPACT OF CASCADE DAMS ON FISH HABITATS AND ALLEVIATION MEASURES IN UPPER YANGTZE RIVER (ONLINE) **Yuqin Lin/Qiuwen Chen**, *professors, Nanjing Hydraulic Research Institute (NHRI), China*	ADVANCED MICRO-SCALE IMAGING METHODS FOR REVEALING BIOGEOCHEMICAL PROCESSES IN SOILS AND SEDIMENTS (ONLINE) **Shiming Ding**, *professor, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, China*
11:45	**COFFEE BREAK AND POSTER SESSION**	
Session VI + VII	**BLUE-GREEN CITY - ADAPTATION TO CLIMATE CHANGE IN THE CITIES OF FUTURE** **Session Chairs: dr Pascal Breil, prof. Tomasz Jurczak**	**THE FUTURE OF ECOHYDROLOGY** **session Chairs: prof. Luis Chicharo, dr Paweł Jarosiewicz**
12:00	KEYNOTE LECTURE: UPSCALING AN ECOHYDROLOGICAL SOLUTION: CASE OF LYON DEMOSITE **Pascal Breil**, *PhD, Riverly Unit, Inrae, Villeurbanne, France*	MOBILIZING AND EDUCATING YOUNG ECOHYDROLOGISTS **Luis Chicharo**, *professor, Department of Biological Sciences and Bioengineering, Centre for Marine and Environmental Research, University of Algarve, Portugal*

12:15	ECOHYDROLOGICAL BIOTECHNOLOGIES FOR WATER QUALITY, QUANTITY AND SECURITY IN ADAPTATION OF CITIES TO CLIMATE CHANGE **Tomasz Jurczak**, *professor, UNESCO Chair on Ecohydrology and Applied Ecology, University of Lodz, Poland*	ENHANCEMENT OF ECOHYDROLOGICAL NATURE-BASED SOLUTIONS FOR SPECIFIC POLLUTANTS REMOVAL **Paweł Jarosiewicz**, *PhD, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*
12:30	GREEN DEAL AND THE CLIMATE NEUTRAL, INTELLIGENT BLUE-GREEN CITY OF LODZ **Anna Wierzbicka**, *Department Director for Environmental Management, City of Lodz, Poland*	LOOKING FOR ALGICIDAL AND MICROCYSTIN-DEGRADING BACTERIA TO ENHANCE THE WBSR+CE APPROACH IN ECOHYDROLOGICAL RESTORATION OF WATER ECOSYSTEMS **Jesus Morón-López**, *PhD, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*
12:45	BLUE-GREEN INFRASTRUCTURE FOR ENABLING ENVIRONMENT IN CITIES ADAPTATION TO CLIMATE CHANGE **Iwona Wagner**, *professor, UNESCO Chair on Ecohydrology and Applied Ecology, University of Lodz, FPP Enviro LTD, Poland*	STUDENTS ASSOCIATION FOR ECOHYDROLOGY – LEARNING BY DOING **Aleksandra Chamerska**, *European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*
13:00	MITIGATING OF URBAN SPRAWL BY CREATING A SMART BLUE-GREEN CITY **Dorota Michalak**, *PhD, Faculty of Economics and Sociology, University of Lodz, Poland*	INFLUENCE OF HYDROLOGICAL CONDITIONS ON NAVIGATION ON THE LOWER VISTULA **Katarzyna Kubiak-Wójcicka**, *PhD, Department of Hydrology and Water Management, Nicolaus Copernicus University, Toruń, Poland*
13:15	WATER IN THE CITY – PUBLIC PREFERENCES FOR BLUE INFRASTRUCTURE IN ŁÓDŹ **Renata Włodarczyk-Marciniak,** *PhD, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*	THE INFLUENCE OF PHYSICO-CHEMICAL PARAMETERS ON FISH AND PELICAN MORTALITIES IN LAKE NATRON RAMSAR SITE (ONLINE) **Clara Yona Mwasota**, *Department of Biosciences, College of Natural and Applied Sciences, Sokoine University of Agriculture, Morogoro, Tanzania*
13:30	RADOMKLIMA – CREATION OF BLUE-GREEN CITY IN RADOM AS IMPLEMENTATION OF GREEN DEAL STRATEGY **Katarzyna Jankowska,** *Department of European Union*	THE FUTURE OF ECOHYDROLOGY IN AFRICA: MOBILIZING YOUTH FOR WATER RESOURCES MANAGEMENT AND ECOHYDROLOGICAL TRANSFORMATION (ONLINE) **Antidious Raphael**, *UNESCO Chair on*

	Funds of the Municipal Office in Radom, Poland	*Ecohydrology and Transboundary Water Management, Morogoro, Tanzania*
13:45	ASSESSING THE IMPACTS OF URBANIZATION ON STREAM ECOSYSTEM FUNCTIONING THROUGH INVESTIGATING LITTER DECOMPOSITION AND NUTRIENT UPTAKE (ONLINE) **Jingmei Yao**, *associate professor, College of Environment and Ecology, Chongqing University, China*	ECOLOGICAL ISSUES OF GUNA-TANA LANDSCAPE, LOCAL COMMUNITY CHALLENGES AND EXISTING INITIATIVES TO TACKLE THE SOCIO-ECONOMIC AND ECOLOGICAL PROBLEMS OF THE AREA (ONLINE) **Hailu Menale Wassie**, *Natural Resource Management, Debre Tabor University, Debre Tabor, Ethiopia*
14:00	**LUNCH & ECOHYDROLOGY SCIENTIFIC ADVISORY COMMISSION MEETING**	
15:00	**SESSION VIII: SUCCESS STORIES - IMPLEMENTATION OF ECOHYDROLOGY THROUGH THE UNESCO IHP DEMOSITES** **Session Chairs: dr Kinga Krauze, dr. Giuseppe Arduino**	
15:00	KEYNOTE LECTURE: EVOLUTION OF ECOHYDROLOGY TOWARDS TRANSDISCIPLINARY SYSTEMIC SOLUTIONS **Katarzyna Izydorczyk**, *professor, European Regional Centre for Ecohydrology of the Polish Academy of Sciences /* **Wojciech Frątczak,** *Director of the Department of Agriculture and Rural Development Programs, Marshal's Office of the Łódź Voivodeship, Poland*	
15:15	CONVERSION OF POST-INDUSTRIAL LANDSCAPE INTO NATURE RECREATION AREAS IN ANTWERP (ONLINE) **Patrick Meire**, *professor, Department of Biology, University of Antwerp, Belgium*	
15:30	TO ALLY TECHNOLOGY, NATURE AND SOCIETY FOR SUCCESSFUL URBAN WATER MANAGEMENT **Kinga Krauze**, *PhD, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Poland*	
15:45	ECOHYDROLOGICAL APPROACH TO RESTORE ANCESTRAL "COCHAS AND TAJAMARES" OF PISACA HILL: WATER SOWING AND HARVESTING IN CATACOCHA, LOJA, ECUADOR (ONLINE) **Marco Albarracin,** *PhD, Fundación Ecohidrológica, Quito, Ecuador*	
16:00	ECOHYDROLOGICAL NATURE-BASED SOLUTIONS FOR BROAD SCOPE OF SUSTAINABILITY PROBLEMS IN INDONESIA (ONLINE) **Ignasius Sutapa,** *professor, Director of Asia Pacific Centre for Ecuhydrology (APCE), Indonesia*	
16:30	PERFORMANCE EVALUATION OF A MODEL CONSTRUCTED RIVER DIVERSION WETLAND FOR IMPROVING QUALITY OF WATER OF AN INLAND RIVER IN KUMASI, GHANA (ONLINE) **Sani Dauda Ahmed**, *PhD, National Water Resources Institute, Kaduna, Nigeria*	
16:45	ECOSYSTEM BASED APPROACH AS A PRIORITY TO SAVE LAKE TANA (ONLINE)	

	Alayew Wondie Melese, *PhD, Department of Aquatic and Wetland Management, College of Agriculture and Environmental Sciences, Bahir Dar University, Ethiopia*
17:00	ANALYZING ECOHYDROLOGY AS PARADIGM SHIFT IN CONSERVATION FOR SUSTAINABLE FLOW OF ECOSYSTEM SERVICES ALONG KIHANSI RIVER CATCHMENT, TANZANIA (ONLINE) **Amina S. Kibola**, *National Environmental Management Council, Nigeria*
17:30	Summary and Conclusions by Chairs of the Symposium Sessions Symposium co-chairs: prof. Maciej Zalewski and prof. Jinsong Guo Session I: prof. Paweł Rowiński, prof. András Szöllősi-Nagy Session II: prof. Edyta Kiedrzyńska, Dr. Elfithri Rahmah Session III: Andrew Allan, Olivier Bouc Session IV: prof. Iwona Wagner, prof. Artur Magnuszewski Session V: dr Pascal Breil, prof. Tomasz Jurczak Session VI: dr Kinga Krauze, dr. Giuseppe Arduino Session VII: prof. Joanna Mankiewicz-Boczek, prof. Iwona Jasser Session VIII: prof. Luis Chicharo, dr Paweł Jarosiewicz

Upsacaling an ecohydrological solution: case of Lyon demosite

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In this study, we examine how ecohydrological analysis of a peri-urban catchment can be used to move from a demonstration site to a large-scale application.
The context is small streams, which drain the hills west of the city of Lyon. These streams have experienced a strong degradation of their physical and chemical qualities with urban development since the 1970s. The granitic nature of the parent rock explains why the fine fraction of these streams is mainly sand. The natural water resource of the catchment area is limited, with non-perennial streams representing 60% of the hydrographic network in dry periods.
Urbanisation has led to morphological rectification by mechanical means, and a degradation of water quality due to the overflow of combined sewerage systems.
The chemical and biological quality data collected over several years in the main watercourses have shown the existence of a variable self-purification capacity depending on the hyporheic and hydrogeological environment of these watercourses.
The ecohydrological management strategy was then organised around the restoration or even the amplification of the factors of this self-purification in the zones which undergo the strongest overflows of the combined networks.
The proof of concept was carried out on a small watercourse 1 metre wide. The construction in 2006 of porous sills across the watercourse allowed the creation of filtering masses, made up of sand transported by the floods. Several research projects have carried out chemical and physical measurements which have shown the capacity of the filters to intercept and biodegrade organic pollution delivered by combined sewer overflows. In the event of high flooding, the top layer of sand is replaced by erosion and deposits. It is therefore a real eco-hydrological solution, because it creates the conditions for a double regulation, based on the one hand on the concentration of nutrient and oxygen flows, using hydrological variability, and on the other hand stimulates the transformation of flows by biodegradation. The feedback from this system provided elements for monitoring and maintenance.
The change of scale was carried out in 2020, in consultation with the authorities in charge of the sewerage systems and watercourses of the catchment area. The study of the dedicated morphological aspects and a hydraulic simulation made it possible to propose four implementations of a porous ramp system in a 5m wide watercourse. After discussion with the authorities and the fishermen's association, two sites were finally selected. The results, acquired since 2021 within the framework of the JPI Water-ATENAS project, show the capacity of interception and biodegradation of the organic matter produced by several storm overflows and the deficiencies of the combined sewerage system upstream. The communication of these results to the authorities should make it possible to propose other sites with an adapted efficiency follow-up.

Vistula river sedimentation transfer dynamics in the perspective of river valley evolution

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The Vistula River is the second largest river in the Baltic Sea basin with a catchment area of 194 × 103 km2. The length of the river is 1047 km and its sources are located in the Carpathian Mountains while its mouth is in the Bay of Gdansk The course of the Vistula corresponds to each of the large spatial units of the physical regions of Poland. The contemporary hydrographic network of Poland was formed as a result of complex geological and morphogenetic processes. The course of the major rivers corresponds to the largest of geological structures; these include the Eastern European and Western European platforms, the marginal synclinorium, the Tertiary Sub-Carpathian Trench, the Meta-Carpathian Rise and the Carpathians. The extreme diversity of climate in the Quaternary period, varying from temperate to arctic, and from dry to wet, contributed to erosion and to sediment accumulation, the development of soil cover and drainage network development. It was also a cause of changes in vegetation, the evolution of the animal world and the development of human civilisation. The morphogenetic factors associated with changes in temperature and the water cycle, endogenous factors, such as neotectonics and isostatic movements, overlapped, as did the role of human activity. As currently believed, the formation of river valleys in the Polish Lowlands was significantly influenced by the periodic release of large amounts of meltwater from the ice sheet, accompanied by the inflow of river water from the southern part of the country. Ice dammed lakes formed at that time, as well as outflow pathways parallel to the edge of the ice sheet leading to unglaciated areas - called spillways - have left ice marginal valleys. 19 th. century has brought a river training works performed differently at subsections of the Vistula river. A good example is the border section between the Prussian and Russian partitions in the vicinity of Silno (km 718). In the regulated section the river channel has been narrowed and straightened and the water flow concentrated, while in the unregulated section there are islands and numerous channel landforms. The lower Vistula River was regulated in years 1856-1878 at distance 718 - 939 km. The regulation plan did not take into consideration the large transport of the bed load. The channel was shaped using the simplified geometry - too wide for a low flow and overly straightened for the stabilization of sandbar movement. The transport of the suspended sediments in the years 1956 – 1965 at the longitudinal profile of the Vistula River shows that the average annual transport of suspended sediment at 877 km was $1.3 \cdot 10^6$ t, while close to the mouth of the river, at 908.6 km, it was 1.2×10^6 t. Inland navigation faces the problem of keeping the minimum transit depths, and the passages between the pools, and the waterway plan is tortuous with sharp turns of small curvature. The pattern of alternate sandbar shift shows around 3 year cycle. The Sentinel satellite images provide a valuable source of information on the channel morphology of the lower Vistula River in the regulated reach. Recorded in late summer, the images from consecutive years are sufficient to detect the changes to the river channel originating from winter and summer floods. Largest average distance of alternate sandbar shift on the Lower Vistula River is from 509 to 548 m. The velocity of movement, calculated as the average shift during one day, was between 1.2 to 1.3 m × day-1.

Temporal interaction between pelagic bacteria and microcystin-producing cyanobacteria as important aspect in water quality assessment

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Climate change and the continuously increasing amount of nitrogen and phosphorus inputs to surface waters, e.g. from intensive food production, have resulted in dangerous cyanobacterial harmful algal blooms (cyanoHABs) on a global scale. In association with cyanobacteria, different communities of bacteria appear in the bloom and may play an important role in the development and degradation of cyanoHABs. Furthermore, the presence of cyanobacteria may influence the dynamics of pathogenic bacteria. Therefore, there is a need to understand the relationships between microorganisms co-occurring in cyanoHABs, at different stages of development, in order to better manage the threat and, moreover, to select beneficial bacteria that limit the outbreak of toxic cyanobacteria. A water retention reservoir in central Poland, representing the conditions of temperate climate of Europe with regular appearance of blooms dominated by toxigenic *Microcystis aeruginosa*, was used to study the above-mentioned interactions. The 16S rRNA gene (region V3-V4) and NGS technology were used to describe the evolution of bacterial communities associated with a summer bloom in 2020 (June, August and October). Bacteria were isolated from a cyanoHAB and characterised for their algicidal potential. The results showed that the cyanobacterial bloom was not abundant in early summer, however, by mid-summer it was enriched with *Aphanizomenon*, *Snowella* and *Microcystis*. In late summer, toxigenic *Microcystis* dominated the cyanoHAB. Furthermore, the bacterial communities associated with the bloom were also dynamic at the time of cyanoHAB development, while pathogenic bacteria were not significantly abundant in early summer when the bloom was not yet fully developed. The highest bacterial diversity and taxa evenness was observed for early summer, with no apparent dominance of genera harbouring potential opportunistic pathogens: *Roseomonas* (7.1%), *Pseudomonas* (3.1%), *Bosea* (2.3%) and *Flavobacterium* (2.1%). In midsummer, another potential pathogen *Lautropia* (8.2%) was noted. In contrast, the family *Sutterellaceae* (24.3%) was significantly abundant in late summer bloom. Bacterial strains from this family have been isolated from human and animal faecal samples, suggesting that they may be potential indicators of water pollution from wastewater. In conclusion, with NGS analyses, it is possible to select periods and sites of particular concern for the occurrence of toxigenic cyanobacteria together with potential pathogenic bacteria or other microorganisms that are biological indicators of water quality. Additionally, in laboratory studies, it was possible to isolate and identify other potential algicidal bacteria belonging to significantly different taxa of Firmicutes (*Exiguobacterium* spp.), α-Proteobacteria (*Kaistia*, *Rhizobium* and *Pseudohoeflea* spp.) and ϒ-Proteobacteria (*Pseudomonas* and *Thermomonas*).

Research funded: National Science Centre 2019/33/B/NZ8/02093 "ALGICYDY".

Sustainable development goals – urgent need for acceleration

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The presentation stresses that water needs to be recognized as the central element in the system of Sustainable Development Goals for it is connected to most of them. If the implementation of SDG-6 is delayed then the other goals will follow a similar pattern. Humanity is already off the track in achieving the SDGs by 2030. The global epidemic will worsen the situation. Added to that, the recent war in Eastern Europe will certainly have a major impact, not only there but also globally. This will likely happen through the significant reduction in agricultural exports, particularly grain. That will likely have ripple effects throughout the developing world, notably in Africa. Therefore, urgent acts are needed at various levels from local to multilateral level to mainstream water in the SDG agenda, particularly to promote nature-based solutions. Ecohydrology, and the relevant network of UNESCO/IHP Centers, do have a major role to play. Fading political will needs to be re-established and manifested by valuing and placing water much higher on the agendas at all levels. Finding science based water policies is the sine qua non for any sustainable development policy. New design methodologies and standards are needed to properly take into account the non-stationarity of hydrological and ecological processes as the current design methodologies, such as for instance, the concept of T-year design floods, developed under the hypothesis of stationary hydrological processes, is not valid anymore. There is growing empirical evidence that due to climate change the length of the return periods of extreme hydrological events, such as floods and droughts, is decreasing. In other words, the inverse of the return period, i.e. the frequency, or the probability of extreme events, is increasing yielding more frequent disasters at both ends of the hydrological spectrum. The combination of the three drivers mentioned above puts the whole SDG system into jeopardy.

Water-ecosystem-food-energy nexus

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Global water issues require far-ranging, efficient and collaborative efforts by the entire humanity to avert disasters in ecosystem functioning, biodiversity, cultural diversity and human wellbeing, specifically for riverscapes. Despite the obviousness of the interdependences between different forms of use and occupation of river basins, the insight that the management of water can *not* be dealt with at *different* geopolitical, administrative, lobby and user levels, is arriving very lately. The "business-as-usual" procedure is still preferred over a harmonized, fair, and holistic management according to the laws of nature. Persistency in archaic behavioural patterns includes the seemingly unstoppable trend to dam up even the smallest river courses, the huge projects for interbasin water transfer, the quest for exploiting ever deeper groundwater layers, and irrational land use, e.g., the production of highly water-consuming agricultural products in increasingly arid zones and the massive transformation of permeable soils with important hydrological buffer functions in to sealed surfaces. Thus, the "marge de manoeuvre" to mitigate problems is shrinking, while options for restoring globally relevant ecosystem functions require more effort and become less probable, as tipping points are approaching fast.

The expression of "water security" should not be wrongly interpreted as an option to quench the thirst of an ever growing and water-demanding human population. Finite resources can never satisfy infinite growth. Acknowledging this implicitness, three consequences follow: First, it is evident that the size of the human population (and that of the human-bred animals and of the human-occupied land surface) has already trespassed the critical limits of global carrying capacity and needs to be controlled. This unpleasant truth is rarely pronounced clearly in statements by the United (human) Nations. Second, the excessive per-capita consumption and the water footprint of specific industries and social groups, needs to be adapted to the carrying capacity of the respective catchments. Third, socioenvironmental justice implies that *all biota (and not only humans) and their ecosystems* do not only have the right to live well but it is also necessary for a sustainable hydrological cycle to maintain and to restore essential ecosystem functions and critical areas.

The water-ecosystem-food-energy nexus (WEFE) approach provides a flexible, adaptable framework to bring these elements together. It promotes the transboundary and transsectoral cooperation of different, so far independently acting social groups and institutions based on the UN Water convention. Analysing the 5 "i"s, i.e., institutions, information, instruments, infrastructure/investments and international cooperation, it identifies storylines and interlinkage types, in order to provide sustainable and equitable solutions for water management. Its procedures and case studies will be detailed in this talk.

Session I

Ecohydrology at UNESCO: an evolutionary program from descriptive to solution-oriented science

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Although officially started in 1996 during the 5th phase of the former International Hydrological Programme (IHP) (1996-2001), this paper attempts, in a preliminary study, to understand how the Ecohydrology concept was designed and conceived in the early stages of the IHP and how it evolved from a pure scientific endeavor to a solution-oriented science which reflects and address the societal, environmental and educational needs characterizing our present times.
UNESCO's Intergovernmental Hydrological Programme (IHP), founded in 1975, is the only intergovernmental cooperation programme of the UN system dedicated to water research and management, education and capacity development. It changed its name in 2019 to Intergovernmental Hydrological Programme.
During IHP 2nd phase (1981-1983), and 3rd Phase IHP (1984-1989) projects were devoted to major hydrological aspects in different endeavors and areas and few of them attempted to consider studies on the effect of "man's" influence on the hydrological cycle and the environment. In IHP III (1984-1989) studies are continued on the line of the activities and studies set up during IHP II, but Theme 4 "Hydrology of particular land areas", envisaged collaboration with UNESCO MAB, in areas such as key landscape areas (wetlands, estuaries, deltas, etc.)
In 1989 UNESCO's Man and Biosphere Programme (MAB) published The Role of Land/Inland Water Ecotones in Land- scape Management and Restoration" which called for a closer collaboration with IHP, in respect to water ecosystems.
While IHP Phases I-II-III, were oriented on International Cooperation in Hydrological Science, the 4th Phase of IHP (1990-1995) holds the title Hydrology and water resources for sustainable development in a changing Environment, with a clear shift from research towards water management. Close links with MAB led to the study of the role of the hydrological cycle in inland-water/land ecotones in landscape management.
Ecohydrology entered into the IHP in 1996, during its fifth phase IHP-V, "Hydrology and Water Resources Development in a Vulnerable Environment" (1996-2001). The conceptualization of Ecohydrology in 1996 came from the joint efforts of both MAB and IHP experts and focused on the understanding of the role of the hydrological cycle in different ecosystems; to identify links between abiotic and biotic indicators to maintain the filtering capacities of flood plains and wetlands, with respect to nutrients and pollutants and the buffering capacity against extreme hydrological events.
IHP-VI (2002-2007) "Water Interaction: Systems at Risks and Social Challenges", besides "water sciences", calls for better understanding of the social, economic and environmental values of water that are interlinked and mutually supportive. In the transition from IHP V and VI phases the notion of "Dual Regulation" is conceptualised and took place in the application of solutions to provide responses to the already occurring challenging on ecosystems; this is based on the interaction between hydrology and biota and on the understanding of the hydrological and biological processes interplay, at scales from the catchment to molecular processes. In 2006 ten demonstration sites were established in different parts of the globe.
The Seventh Phase IHP-VII (2008-2013) named "Water Dependencies: Systems under Stress and Societal Responses" has Theme 3 "Ecohydrology for sustainability" to contribute to a better understanding of water as both an abiotic resource and a service delivered by ecosystem processes,

to identify, quantify and improve the critical interrelationships between water and biota, necessary for sustainability, particularly in critical ecosystems. In 2011, 32 demonstration site projects were presented, grouped into four different categories; global reference projects, operational projects, evolving and emerging projects.

The Eight Phase IHP-VIII (2014-2021) addressed the overarching theme: "Water security: Responses to local, regional, and global challenges". Theme 5 out of 6 is dedicated to "Ecohydrology: Engineering harmony for a Sustainable World". The concept is based on the theory to regulate hydrological and nutrients' cycles in "novel ecosystems" towards the enhancement of carrying capacity of global ecosystems, understood as the improvement of ecosystem properties such as water resources, biodiversity, ecosystem services for societies, the resilience to increasing various forms of impact (including climate change), culture and education (WBSR + CE).

From 2006 to 2019 eight Centres under the auspices of UNESCO and UNESCO Water Chairs were established in Europe, Latin America and the Caribbean, Africa and Asia. Their continuous support coupled with both research and educational activities is greatly contributing to the success of the Ecohydrology programme. At the end of 2021, 29 demonstration sites in 20 countries around the world were operational, applying solutions to enhance ecosystem properties therefore providing valuable services both to nature and humans.

The Ecological Civilization Paradigm for Lake Restoration: China's Lake Hongfeng

Shahbaz Khan

Director and Representative, UNESCO Office Beijing

The notion of "ecocivilization" is the Chinese answer which incorporates environmental, economic, educational, political, agricultural and other societal reforms toward sustainability in a whole-of-system approach. China is a global champion of the concept of "ecological civilization", which was enshrined in its Constitution in 2018. Since then, China has been developing this concept in greater depth and at a faster pace, placing ecological civilization on the agenda of its five-in-one national modernization process.

Recently in October, the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity (COP15) is held in Kunming, southwest China's Yunnan Province. As the major achievement of the conference, The Kunming Declaration was adopted to ensure the development and implementation of the post-2020 global biodiversity framework to reverse the current loss of biodiversity and secure its recovery by 2030, which will lead to the fruition of the 2050 Vision of "Living in Harmony with Nature." As the host and the chief protagonist of the conference, China has demonstrated its staunch determination in taking the leadership to promote international cooperation on ecological development and environmental protection. In his speech during the leader's summit of COP15, President Xi has emphasized 1) the overarching role of the concept "ecocivilization" as the fulcrum which sustains the balance between human society and nature; 2) the green transformation, that is, a green low-carbon recycling economy as the driving force to help global sustainable development; 3) focusing on people's welfare to promote social equity and justice, as the guiding principle of all policies and actions; 4) anchored on the basis of international law, maintain a fair and reasonable international governance system that truly manifest multilateralism, combine ambition and pragmatism.

UNESCO Office Beijing is working on Hongfeng Lake in the Guizho Province in China to demonstrate ecological civilization concept through UNESCO's natural sciences programmes such as the Intergovernmental Hydrological Programme (IHP) and Man and Biosphere Programme (MAB), which are key promoters of sustainability and green societies. This multi-scale inter-sectoral approach is bringing together following activities:

- Promoting best practices of eco-civilization and sustainable management of the Hongfeng Lake Ecohydrology demonstration site;
- Setting up of environmental and integrated water resources management education center in cooperation with China Railway Real Estate Group Dream River project and ASPnet Schools;
- Reporting the key findings at dedicated sessions at the Eco-civilization Forum in Guiyang through UNESCO designated sites for up-scaling eco-civilization.

Carbon as a new dimension of ecohydrology: lessons from reservoir GHG emissions

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Dam construction and reservoir creation are typical human activities to regulate or manage water reservoirs. It was not until the 1990s that GHG emissions of reservoir creation has become global concern. The paper synthesized state-of-the-research on reservoir GHG emissions and carbon footprint of hydropower over the past three decades. From the global perspective, hydropower is still a low-carbon energy compared with fossil fuels. Quantification of GHG emissions is not the end to evaluate anthropogenic activities in damming and managing water resources. Yet, carbon has become a new dimension in ecohydrology towards climate neutrality by the mid 21st century. Ecohydrology serves as a theoretical basis of innovation for sustainable water resources management. Outcome of the research will help scientists and policymakers to gather information and make right choices and solutions.

Ecohydrology for Water Security in the Global South:

Cooperative Solutions for Transboundary Challenges

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The UNESCO-IHP-Phase IX (2022-2029) incorporates Ecohydrological Sciences for water security in a changing environment. Impacts of COVID pandemic and food insecurity accelerate the usability of ecohydrological nature-based solutions (EH-NbS)[a], as cooperative as transboundary. We here share recent interdisciplinary examples of EH-NbS linked to the "WBSRC"[b] (Water, Biodiversity, ecosystem Services for society, Resilience to climate change, and Cultural heritage), namely: circular framework with feedbacks, scales and stakeholders [c]; multi-stage disaster risk reduction (DRR) management [d]; ecosystem-based valuation using water footprint[e]; water-quality scenarios of ecosystem-based adaptation [f]; modular bioretention systems for sustainable stormwater management [g], allied with online, in-situ water quality monitoring[h] and digital twins [i]; citizen science and low impact development [j] combined with stormwater systems optimization [k]. Moreover, socio-economic EH-NbS for WBSRC are DRR-insurance for water utilities under climate change [l] linked to stormwater reuse [m]. With the augmenting inequality in the Global South, these feasible EH-NbS can be adapted at low cost layouts, by participatory schemes and serious games, to thrive circular economy, zero-net transition and peace around the Agenda 2030.

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Ecohydrology in the Intergovernmental Hydrological Programme IX 2022-2029

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Ecohydrology was first introduced within the framework of UNESCO Intergovernmental Hydrological Programme (IHP) V 1991-1998 as a new paradigm for the sustainable use of aquatic resources which could help solve the main problem of loss of ecological quality of water, at the basin scale. This approach meets the need for a better integration of the efforts of the scientists representing the three disciplines i.e. hydrology, ecology and social science, which integrated three critical issues i.e. water, nature and people, and increasing the chances for a better addressing the rising global challenges, and elaborate innovative solutions. The UNESCO Ecohydrology Demonstration Site was launched in 2010 to identify opportunities to demonstrate the application of the ecohydrology approach to solve issues surrounding water, environment and people. It focused on an integrated understanding of biological and hydrological processes at a catchment scale in order to create a scientific basis for a socially acceptable, cosft-effective and systemic approach to the sustainable management of freshwater resources in a variety of ecoystems and climatic zones. Demonstration Sites allowed the validation of the concept in multiple geographical areas, different climates and ecosystems, also considering diverse social contexts, with a total of 29 Sites in 19 countries by the end of 2021. Ecohydrology in the IHP IX 2022-2029 is focusing on the development, enhancement and dissemination of scientific research knowledge products on Ecohydrology including the promotion and establishment of new Ecohydrology Demosites and the development of Ecohydrology Approach within UNESCO-Designated Sites (Biosphere Reserves, World Heritage Sites and Global Geoparks) and building capacity for improved water management. Ecohydrology as a transdisciplinary sustainability science will be promoted strategically in tandem within UNESCO Water Family and Demosites Network towards achieving a water secure world in a changing environment.

Session II

Ecohydrological approach to water resources health analysis and anthropogenic pollution from global to river catchment scale

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The impact of the human population on the global water resources is so huge that it is the dominant force behind changes in water resources across the world. Already, about 30% of Europe's population is affected by water stress during an average year. The situation is expected to worsen as climate change is increasing the frequency, magnitude of droughts (IPCC 2018; UNEP 2021), which, combined with anthropogenic impact, leads to the reduction of environmental resilience of freshwater and marine ecosystems. Therefore, it is critical to use our knowledge on water – ecosystems interplay to provide sustainable management tools and create local, regional and global adaptation strategies.

Most human activities that use water produce wastewater. As the overall demand for water grows, the quantity of wastewater produced and its overall pollution load are continuously increasing. The global freshwater withdrawals are estimated at 3,928 km³ per year, and around 56% (2,212 km3 per year) is released into the environment as wastewater in the form of municipal and industrial effluent and agricultural drainage water (FAO, AQUASTAT database). The consequences of releasing untreated or inadequately treated wastewater can be classified into three groups: i) harmful effects on human health; ii) negative environmental impacts; and iii) adverse repercussions on economic activities (WWDR, 2017). It is estimated that more than 80 percent of all wastewater resulting from human activities is discharged into rivers, lakes or seas without any pollution removal.

The main objectives of the ecohydrological research led in Poland were: (1) demonstration how ecohydrological Nature-Based Solutions can be combined with conventional infrastructure to improve WBSRCE benefits (Water, Biodiversity, ecosystem Services, Resilience, Culture, Education) by taking a holistic approach to lateral reservoir design (Kiedrzyńska et al., 2021); 2) evaluation of the most significant anthropogenic factors determining eutrophication of the Baltic Sea (Kiedrzyńska et al., 2014a); (3) evaluation of the role played by WWTPs in contamination of the Pilica River (Kiedrzyńska et al., 2014b); (4) elaboration of the innovation hybrid sequential biofiltration system for wastewater purification (Kiedrzyńska et al., 2017).

Research conducted in the Pilica River catchment concentrate on the analysis of hydrological processes and the following contaminations: chemical (nutrients, dioxins, heavy metals, surfactants), and microbiological pollution, and drug resistance (antibiotic-resistant bacteria - ARB, antibiotic-resistant genes - ARG), which affect ecotoxicity state of waters. These interdisciplinary and innovative studies bring new and utilitarian knowledge about the spread and transformation of pollutants in the catchments of rivers to promote a better understanding of ecosystem health and the

scale of pollution and also to encourage sustainable social practices, especially in the Baltic Sea region.

The research was conducted within the projects: 1/ of the National Science Centre, Poland-2015/19/B/ST10/02167; 2 / of the Polish Ministry of Science and Higher Education - NN305 365738; 3/ of the National Centre for Research and Development, Poland-TANGO 2/339929/NCBR/201, and also 4/ of the National Science Centre, Poland- 2021/43/B/ST10/01076.

Nature-Based Solutions and Ecological Engineering: Our best hopes for restoring lakes, rivers, and estuaries and protecting human health

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Nature-based solutions are sometimes defined as "building with nature and for nature." It is really a re-invention of Ecological Engineering that is well established with an Elsevier journal and several textbooks over the past 30 years. Ecological engineering was described by Mitsch and Jorgensen as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both." So both practices agree that nature needs to benefit as well as humans. Supporters of nature-based solutions suggest that, in addition to having a basis in ecological engineering, Nature-based solutions also borrow from other ecological paradigms such as natural capital, green and blue infrastructure, and ecosystem services. Examples of restoration strategies in the Florida Everglades will be illustrated, some of which clearly are nature-based solutions and some of which clearly are not. Wetlaculture is a relatively new ecological engineering approach for developing sustainable agriculture in a wetland landscape or developing wetland ecosystems in an agricultural landscape. Several peer-reviewed papers and unpublished theses and dissertations have shown the advantages of wetlaculture practices in mesocosm experiments over the past decade in Ohio and Florida where the practice could help solve downstream nutrient pollution problems by decreasing the amount of fertilizers added to landscapes for crops.

Ecohydrological Nature Based solution for Harmonization of Lake Tana shore Ecosystem and Societal needs, Bahir Dar, Ethiopia

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Lake Tana is the source of the Blue Nile River and is the largest fresh water lake in Ethiopia that comprises more than 50% of the total freshwater of the country. It has multiple uses including fishing, drinking, tourism, transportation, electricity. Despite these social and ecological benefits, Lake Tana is threatened by sedimentation, pollution, eutrophication and invasive weed (Water hyacinth and decline of biodiversity. The degradation of shoreline vegetation dominated by papyrus has been reduced to one tenth due to the recession farm leading to/ causing to/resulted in loss of assimilation capacity and loss of spawning grounds for the fish inhabiting the lake. Ecohydrological Nature Based solutions (EH NBS) embedding circular economy principles was implemented with the objective of rehabilitation of the lake shoreline vegetation mainly papyrus, with simultaneous enhancement of livelihood through transforming linear agriculture (recession farm) into circular agriculture. The EH NBS intervention has systemic solution: fish pond-small irrigation -wetland–cut and carry feeding system-biogas–horticulture designed in such a way that waste from one component could be used as an input for the next component. Circular agriculture is aimed at closing the loop of materials and substances, and reducing both resource use and discharges into the Lake Tana. The study was conducted in 2019 and 2020 to assess 1, Physico-chemical parameters of sediment and water, 2, the relative abundance of macrophytes, macro invertebrates, zooplankton, phytoplankton taxa and 3, socio economy of three sites: the rehabilitated shore line integrated with circular agriculture, 2, degraded shore line under pressure of recession farm and 3, shore line invaded by water hyacinth. The study confirmed that the family who converted linear agriculture by Circular one with simultaneous rehabilitation of the lake shore vegetation-papyrus became the most benefited from diversified livelihood sources while improving abundance and diversity of biological groups, water quality and ecosystem services.
The opposite situation was observed in the other two shore ecosystems. The overall result verified the possibility of living in harmony with nature, even with enhanced livelihood of society and ecosystem services of Lake Tana shore if Ecohydrology Nature Based Solution is employed. I recommend awareness rising ranging from decision makers to the people on the ground and expanding circular agriculture surrounding the lake.

Key words: awareness rising**,** biodiversity, circular agriculture, ecohydrology, harmonization macrophytes, macro invertebrates, nature based solution, linear agriculture, socioeconomic, phytoplankton shoreline vegetation degradation, papyrus, lake Tana, zooplankton

Principles of development of a Polish-Ukrainian transboundary groundwater monitoring network

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Recently, there has been growing interest in the issues of monitoring and status assessment of transboundary groundwater aquifers. The studies of transboundary groundwater flows in the Polish-Ukrainian borderland as part of the EU-WATERRES project (www.eu-waterres.eu) justify the legitimacy of establishing a transboundary groundwater monitoring network. In order to support internationally integrated management, the principles of designing the Polish-Ukrainian transboundary groundwater monitoring network were developed in relation to the needs of assessing their quantitative and chemical status. The recommendations were prepared taking into account the potential of the existing national networks and the requirements of EU law. For this purpose, the criteria for locating groundwater observation points of transboundary monitoring were developed and a spatial GIS analysis of environmental and hydrogeological conditions was performed .

The spatial extent of the transboundary aquifers and groundwater flows identified in the EU-WATERRES project on the basis of a common hydrodynamic model necessitated a new look at the usefulness of national monitoring points in border zones for the purposes of cross-border monitoring. The performed analysis of the representativeness of the existing points showed that only 8 out of 19 border points of the national groundwater monitoring networks of Ukraine meet the requirements of cross-border monitoring. Similarly, in Poland, out of 14 points in the border area, only 6 qualified for the cross-border network. The insufficient number of points resulted in the identification of places for the location of new facilities. As a result, 7 prospective areas were identified for the development of the cross-border network in Ukraine and 5 – in Poland. The transboundary groundwater monitoring will include the measurements and tests of the following groundwater status indicators:

- level of the groundwater table,
- studies of the physical-chemical elements of groundwater, characterizing the substances of geogenic and anthropogenic origin.

Session III

Why do lawyers need knowledge of WBSRCE (Water, Biodiversity, ecosystem Services, Resilience, Culture, Education)?

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The paper illustrates a new paradigm for understanding law. This new approach is noticeable in the case of the Whanganui River, which has been granted legal personhood. The idea of recognising elements of nature as having legal personality has been around for many years, as part of proposals for a new approach to ecology. From a typically legal perspective, the clear arguments for extending the concept of legal entity to environmental elements deserve attention. Nature is in need of protection and, in order to receive it, it should obtain legal personality and its own independent rights, so that it can sue entities that harm it and receive appropriate compensation.
One of the fundamental principles of sustainable development is maintaining the dynamic balance of ecosystems. This is of critical importance because if an ecosystem is subjected to overexploitation and its biotic structures are degraded, it reaches a point where its bioproductivity becomes insufficient, or even impossible. Currently, biodiversity is one of the most important concepts in contemporary law focused on the protection of nature and the environment. The level of biodiversity is a crucial factor for achieving sustainable development objectives on global, regional and local scales, as well as for the implementation of the principle of justice between generations.
Recognition of nature's inherent rights as a subject, and their acceptance and incorporation into the legal system, requires not only changes in the law, but also a paradigm shift in thinking about the legal system: one which places human beings at the centre, but also takes into account the needs of other living beings and nature as a whole. However, the attempts to introduce this construction have been made in response to the inefficiency of the existing environmental protection system, the evident need to the search for more effective instruments, and the awareness of the need to develop an alternative worldview that can replace the prevailing one. In this context the right to water should be regarded as a subjective right of nature, in other words something more than a third-generation human right. It is a right belonging to all living organisms and nature as a whole, including the inanimate part.

Law and Challenges of Sustainability

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The aim of this presentation is to demonstrate that although the awareness concerning importance of water in the context of sustainable development goals changes, it is not reflected in judicial decisions. Several case studies indicate that this state of affairs seems to be influenced by old paradigm of economic growth. One of the reasons for such flawed perspective occurs is a utilitarian perspective dominated by the conviction that the well-being of the society is determined by economic growth measured by GDP. Such a perspective disregards the fact that there are better indicators of human well-being (Constanza et.al).

There are three ways of tackling this problem. First, the awareness of judges of the new measures of progress should be increased. This, however, involves interfering with their own, sometimes strong, views on economy and hence might be inefficient. Second, new attitudes can be enforced by law. Such a solution could be a quick fix, provided that decision makers are eager to introduce them. Third, the change of paradigm of their thinking will change – from Utilitarian into Rawlsian. This solution requires additional training of judges.

The optimal gain would occur if all three factors were fulfilled altogether; however, it is unlikely that this will be the case everywhere. Therefore, it is crucial to introduce them regarding the local context and culture and balance their utility in this context.

This presentation will tackle with the third solution focused on Rawlsian paradigm. It will be argued that judges rule not free from personal bias which includes contemporary perspective disregarding future generations perspective. The conceptual tools provided by John Rawls dubbed 'original position' and 'veil of ignorance' are able to remove bias and include the perspective of future generations in judicial thinking, offering a new paradigm of thinking in terms of WBSR + CE as a holistic approach.

Session IV

Molecular approach to infer self-purification potentialities of river system

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Carbon and energy budget in river systems are dominated by processes associated with detrital organic matter, and mediated by microbes. Microbial degradation of dissolved and particulate organic matter and the ensuing detritus based food webs are critical to ecosystem functioning and affect the overall ecology of freshwater systems.
Microbial communities are therefore major players in the biogeochemical processes and ecosystem functioning of river networks. This functional role is particularly true for the microbial communities living in epilithic biofilms with a high sediment to water phase ratio, producing a large extent of reactive surfaces in streams. In flowing waters, biofilms constitute the major component for the uptake, storage and cycling of carbon, nutrients and anthropogenic contaminants. Despite their importance in the ecosystem, biomonitoring tools relying on prokaryotes are still lacking.
In this context, here we present results from different geographical regions and we discuss how mapping microbial diversity, and the functional traits related to key ecosystem processes, has huge potential in increasing our understanding of drivers of ecosystem functioning and in the self-purification potentiality of riverine systems. Moreover, due to their high sensitivity to pollution and fast response to environmental changes, bacterial assemblages could complement the information as indicators of human-induced impacts.

Elucidating the biotechnological application of nitrogen-transforming bacteria for the future improvement of nature-based solutions

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Nitrogen pollution is a major environmental problem that particularly affects freshwater ecosystems. High inflow of inorganic nitrogen species (NH_4^+, NO_2^- and NO_3^-) lead to accelerated eutrophication of lowland waterbodies resulting in the appearance of toxic cyanobacterial harmful algal blooms (CyanoHABs) that can severely affect biodiversity and human health. To avoid such problems, nature-based solutions (NBSs) should be implemented at strategic locations within a catchment to aid in water treatment. One of these proposals is the sequential sedimentation-biofiltration system (SSBS), which is a multi-zoned biofilter constructed within the course of urban rivers, mimicking different natural processes involved in water depuration, e.g.: sedimentation lagoons, phosphorus adsorption in limestone barriers, and phytoremediation in constructed wetlands. In our studies, nitrogen-transforming bacterial communities were observed to be significantly abundant within sediments and biofilm formations in SSBSs, suggesting that they have an important effect on the overall nitrogen removal efficiency of the system. Considering that bacteria are known to be keystones in the nitrogen cycle, the above observations led our interest to investigate the biotechnological potential of selected SSBS bacterial strains in the transformation of nitrogen. In the next step of our study, culturable bacteria were isolated from SSBSs sediments and tested for their abilities to transform nitrogen species during screening assays. From a total of 150 strains, only 10 utilized nitrogen species, which according to the 16S rRNA gene, belonged to Actinobacteria (*Kocuria*), Firmicutes (*Bacillus*), β-Proteobacteria (*Janthinobacterium*, *Acidovorax* and *Hydrogenophaga*) and ϒ-Proteobacteria (*Citrobacter* and *Pseudomonas*). Two strains, *Citrobacter freundii* Bzr02 and *Pseudomonas mandelii* Str21 were furtherly investigated due to their higher performance in nitrogen removal during the screening assays. The strain Bzr02 removed up to 99.0% of $N–NH_4$ and 70.2% of $N–NO_3$, while Str21 up to 98.9% of $N–NH_4$ and 87.7% of $N–NO_3$. Genetic characterization of selected key functional genes involved in dissimilatory nitrogen reduction indicated that Bzr02 participated in the transformation of nitrate to nitrite (*nap*A/*nar*G), and the removal of hydroxylamine (*hao*) – a toxic intermediary product in the process of nitrification, while Str21 was performing complete denitrification (*nar*G, *nir*S, *nor*B, and *nos*Z). Furthermore, it was observed for both strains that nitrogen assimilation was also an important process occurring simultaneously with denitrification. Based on these results, both strains show biotechnological potential for the transformation of nitrogen compounds. They are excellent candidates as microbial activators to increase the removal efficiency in future SSBS constructions, and could also be extended to other NBS.

Funds: National Centre for Research and Development TANGO2/339929/NCBR/2017 “AZOSTOP”

A novel methodology for rapid *in situ* assessment of the high-resolution spatial and temporal distribution of cyanobacterial blooms using fishery echosounder

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Cyanobacterial blooms are increasing in frequency, magnitude and duration globally due to enhanced eutrophication and climate change. Thus, comprehensive investigation and systematic monitoring of the spatial and temporal distribution of cyanobacteria in aquatic environments is urgently needed to better understand bloom development and complex interactions with the dynamic environment. Various methods have been used to investigate cyanobacteria distribution, including traditional point sampling of water, fluorometric measurement, and satellite remote sensing. However, none of the methods can provide high-resolution data for the three-dimensional spatial structure of the bloom and its dynamics in time. It is, therefore, essential to incorporate modern high-resolution technologies for *in situ* monitoring of cyanobacteria. This gap may be fulfilled by hydroacoustic methods, which allow for rapid scanning of water column synoptically and have a significant potential for quantitative observation on the spatio-temporal variability of gas-containing cyanobacteria. In the present study, we investigated the applicability of high-frequency (200 kHz) fishery echosounder, widely used in fisheries acoustics, to detect and estimate the cyanobacterial genus *Microcystis* bloom distribution and biomass in a shallow lake (Sulejów Reservoir, Poland). Verifying the usefulness of *in situ* acoustic quantification of bloom-forming cyanobacteria was based on comparing acoustic estimates of cyanobacteria biomass with the ground truth, *i.e.* fluorometric measurements and chlorophyll *a* concentrations. The area sound backscattering coefficient, sA (m^2ha^{-1}) measured by the echosounder, was used to proxy cyanobacteria biomass. The comparisons of acoustic estimates with other methods were performed for continuous measurements along the ten pre-determined parallel transects and point samples at 14 stations situated on the transects. In the vertical hydroacoustic measurements at night, we observed that cyanobacteria biomass was highest in the upper-most layer and diminished continuously with depth. For both, horizontal and vertical continuous measurements, we found significant positive correlations between acoustic and fluorometric estimates of cyanobacteria biomass. However, the traditional point measurements did not agree equally well with the acoustic estimates, especially for vertical beam. We argued that the point measurements have more stochastic character and less adequately describe dynamic changes in cyanobacteria distribution than continuous acoustic estimates. More studies are required to explore the cyanobacteria distribution patterns under different biological, physical, and meteorological conditions.

Sustainable management of National Parks requires inclusion of river catchments Upstream

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Wildlife in Tanzania national parks are strongly dependent on water supply from rivers that have their catchments located outside protected areas, in community lands. Ever-increasing grazing pressure from livestock, bush fires, deforestation to cropland, irrigation and other associated catchment degradations are progressively affecting river flows with consequences for biodiversity conservation. TANAPA, which is the Authority managing the National Parks of Tanzania, has taken proactive initiatives and actions to understand the causes and effects of the water crisis in its National Parks, principally the Serengeti, Tarangire, Ruaha, Katavi, Rubondo, Saadani, Arusha and Lake Manyara National Parks. An analysis of monitored river discharge data in selected rivers from those parks have shown that unsustainable water resource management outside national parks are the causes for declining river flows. These initiatives and actions have followed the ecohydrology guidelines for water management and they vary from Park to Park according to the local conditions. There are limits to what TANAPA can achieve by itself to save its National Parks from the water crisis, because TANAPA has no control on activities outside the Parks. Because it is known that river flow dynamics are significantly impacted by land-use and deforestation upstream. Given that national parks are delineated following seasonally used ranges especially for migratory wildlife species, while excluding river basins; will further continue to affect river flow and surface water availability for wildlife use. It is now emerging that there is a concern that if the current national park management cannot consider a basin wide integrated approach, there are high chances of driving wildlife ecosystem into collapse. This means that if the current rates of land use changes and water abstractions in combination with the expected climate change impacts are not properly addressed and effective interventions instituted, the future water supply of the rivers in the national parks are at risk which will have major consequences for its people and wildlife. Ecohydrology-based solutions are urgently needed.

The Role of River Health Assessment in Water Resources Management: A case Study of Ruvu and Simiyu River Catchments in Tanzania

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Catchment degradation is the major issue in water resources management, and as a result, impacts a wide range of economical, societal and environmental aspects. In many cases catchment degradation is associated with changes in hydrological and ecological features and functions of rivers. Increasing degradation caused by uncontrolled human activities poses a need for basin water boards to understand the inherence and levels of such degradation activities within basins. Ecohydrological approaches to assess the health and integrity of rivers are therefore vital. River health assessment using ecohydrological variables was conducted in Ruvu and Simiyu catchments in Tanzania in 2017 and 2019 respectively to assess types and levels of degradation. Catchments were longitudinally demarcated based on slope ranges. The Eco hydrological variables collected included biological (macroinvertebrates and diatoms), hydrological (discharge, depth and velocity) and physical (pH, temperature, conductivity, and Total Suspended Solids) were done in all river zones. In addition, the investigation covering condition of the local catchment (extent of human disturbance) was also conducted in parallel. In characterizing the biotic assemblages, the Tanzania River Scoring System (TARISS) was used and the most representative species for spatial variation were identified and assessed in relation to degradation. Other Eco hydrological variables were assessed using Spearman rank correlation. Results in Ruvu catchment showed that Ngerengere sub catchment has been impacted more than Upper Ruvu sub catchment. Rivers Mlali Lukurunge and Ngerengere were among the most affected river sites in Ngerengere sub catchment where river Mzinga at Ruhungo had higher habitat integrity, discharge, and aquatic macroinvertebrates. In Upper Ruvu, rivers Ruvu at Kibungo, Mgeta at Bunduki and Mbezi at Kinole had higher scores showing moderate to largely natural indices for both abiotic and biotic indices while rivers Mzinga at Langali, Ruvu at Magogoni, Mgeta at Duthumi, Mvuha at Tulo and Mfizigo at Kifindike were largely and seriously modified. In Simiyu catchment, results showed areas of Simiyu at Lumeleji is of least impacted while Duma at Nyakabindi, Simiyu at Marita, Simiyu at Ng'ang'a are of moderate impacted. The largely impacted areas in which the basin needs to intervene are of Ididi, Duma at Kasamba, Simiyu at Itilima, Mwirumi and sola. The assessment also identified three main drivers of change in the catchments being poor agriculture practices, pollution and water abstraction. Hence the findings supported the water resources initiatives and focus the resources.

Keyword: River health, Ecohydrological variables, Water Resources degradation, Spatial variation, Simiyu River and Ruvu River

Impact of anthropogenic disturbances on water availability in Mongolian urban and mining hubs towards effective utilization of water resources

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In Mongolia, overuse and degradation of groundwater is a serious issue, mainly in the urban and economic hub, Ulaanbaatar, and the Southern Gobi mining hub (Banerjee et al., 2014). In order to evaluate the impact of anthropogenic activities on water availability, a process-based eco-hydrology model, NICE (National Integrated Catchment-based Eco-hydrology) (Nakayama and Watanabe, 2004), was applied to two contrasting river basins including these hubs (Tuul and Galba River Basins). The author built a high-resolution grid data representing water use for livestock, urban populations, and mining by combining a global dataset, statistical data, GIS data, observation data, and field surveys in order to improve the accuracy of the model results.

NICE simulated the effects of climatic change and human-induced disturbances on water resources during the last four decades (Nakayama et al., 2021). The model clarified that the groundwater level in the Tuul River was shown to have been extremely degraded by water use in Ulaanbaatar over the last few decades whereas that in the Galba River has declined markedly as a result of Oyu Tolgoi mining since 2010. Analysis of the relative contribution of environmental factors also helped us to separate the effects of climatic change and human activities on spatio-temporal change in the groundwater level.

Further, the author extended NICE to couple with inverse method for sensitivity analysis and parameter estimation of anthropogenic water uses (NICE-INVERSE). This new model quantified the spatio-temporal variations of livestock water use in these river basins (Nakayama, et al., 2022). NICE-INVERSE also showed a temporal decreasing trend of unit water use in some typical livestock (cattle, sheep, and goats), suggesting a substantial increase in water stress due to local-regional eco-hydrological degradation by urbanization and mining (Banerjee et al., 2014). This means the sensitivity analysis and inverse estimation of model parameters helped to improve the accuracy of hydrologic budgets in basins.

This methodology is powerful for evaluating spatio-temporal variations of water availability towards effective utilization of water resources in regions with fewer inventory data. It is also powerful to predict and resolve future competition for water resources that could potentially trigger conflicts between urban, mining companies, herders and local communities.

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Nature Based Solutions – chances and constrains from river basin perspective.

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Various types of measures listed under the name of Nature Based Solutions can have significant positive effects on solving environmental problems such as hydrological extremes, nutrients' transport and decreased biodiversity (www.nwrm.eu) Number of restoration and conservation projects show the positive effect of single measures on river re-meandering, lakes restoration, wetlands restitutions, floodplain revitalisation etc. on water storage, sediment trapping or nutrients capturing. We observed, however limited integration of NBS in the river basin and flood risk management plans in Europe. It is caused mainly by lack of knowledge base and tools on how to plan, assess and implement the multiple benefits of number of measures applied in a catchment.
We have tested different approaches in modelling of several river basins where restoration activity or buffering measures where applied or planned. This includes Kamienna River in upland landscape, Słupia River in costal settings and Pilica River in lowlands. There were also modelling experiments conducted on rivers in Finland, Sweden and Lithuania. Based on the modelling experience from these catchments using Soil and Water Assessment Tool (SWAT), where different types of river buffer zones and wetlands implementation has been tested, a number of challenges can be emphasized. At a general level, three major sources of challenges dominate: (1) spatial extent and location of measures, (2) their accurate parametrization and (3) simplification of processes in modelling scheme. Most commonly, in semi-distributed models, principal calculation units for which water and nutrient balance is calculated, are lumped and non-contiguous geographic units within each sub-catchment. Particular model setup may consist of thousands of such units, and each of them may represent one field, a portion of a field, or, more likely, portions of many fields. It becomes problematic when we aim to simulate measures for particular river reach or wetland, but can only define it at coarser sub-catchment level. The second issue is related to proper parametrization of empirical/physical sub-models, simulating processes of nutrients adsorption and settling. In most cases, uncertainty related to parametrization of buffer zones and wetlands is significant. No simple calibration procedure for setting the optimal parameters' values can be applied, and the process itself is more expert-dependent. Another issue is related to simplifications of processes. For instance, in SWAT, nutrient transformations simulated in wetlands are limited to the removal of nutrients by settlings however transformations between nutrient pools are ignored. For the buffer zones, model only affects contaminants that are present in surface runoff and neglects the potential effects of buffer zones on shallow groundwater.
Regardless of the broad acceptance for applying NBS as a tool for improvement catchments performance in terms of hydrological extremes and pollution, there is a small science based evidence for quantitative impact of small and natural retention measures on flood and drought mitigation or water quality improvement. So far developed tool have to rely on experts knowledge for cumulative effectiveness and but should be supported by hydrological modelling for verification. This field of hydrological modelling is still open for new initiatives both on an approach as well as on data development.

Assessment of habitat around barriers with habitat model MesoHABSIM for selection of river management alternatives

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Over a million barriers fragment European rivers altering riverine fish communities habitats and herewith causing considerable harm to aquatic biodiversity. Reducing this footprint is a set goal of EU Biodiversity strategy 2030. Reaching it calls for introducing strategically planned and cost effective restoration actions to recover habitat for the communities of free flowing rivers. Physical habitat simulation models are powerful planning tools allowing to simulate and quantitatively predict future outcomes of human actions. They can be applied to identify effective restoration scenarios also taking into account the future of changing climate. This article presents few case studies where MesoHABSIM model and Restoration Alternative Analysis are applied to investigate management options. Furthermore, Ask-The-Fish approach for evaluation and selection of biologically effective habitat restoration measures with help of MesoHABSIM is demonstrated. This work has been performed with support of Horizon 2020 funding by European Commission provided to a multinational research project Adaptive Management of Barriers in European Rivers (AMBER).
Keywords: dams, climate change, habitat models, restoration planning

The use of ecohydrology to solve the threat from climate change and dams to the Burdekin River delta and coast, Great Barrier Reef, Australia

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The Burdekin River is located in the dry tropics of Australia with a seasonally and interannually highly variable discharge, controlled by occasional cyclones and the ENSO-dependent monsoon. Even though the peak discharge from cyclonic rainfall is decreased by a dam, large floods still occur during long-duration monsoon. While the dam traps much of the coarse sediment runoff, large amounts still reach the Delta originating from catchments downstream of the dam. The riverbed in the Delta has measurably accreted in recent decades. In turn, this increases the flood levels and the threat of channel avulsion. Sand trapping by the dam and in the Delta is also starving the coast of sand, and this generates rapid coastal erosion along the 11 km long Cape Bowling Green peninsula. Climate change is enhancing this coastal erosion and threating to breach the peninsula, as in the last few decades the mean sea level and the frequency of strong winds have increased measurably. As the peninsula protects Ramsar-listed wetlands of international significance, its breaching is predicted to impact the fisheries that depend on the Cape (the black marlin billfish) and on the wetlands (mud crabs, barramundi and mangrove jacks), as well as shorebirds and waterbirds. These findings demonstrate the connectivity of water and sediment throughout the river basin and the coast, and the need for management at the basin scale using ecohydrology principles, which would involve working with nature.

Session V

Microbial and chemical quality assessment of the small rivers entering the Baltic Sea

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In the area of the Coastal Landscape Park (CLP), which is undoubtedly a very attractive area for tourists, the population density increases dramatically during the summer season. There is a risk that the domestic wastewater collected by the local WWTPs might not be sufficiently treated before being discharged into the rivers and streams. The research was conducted to assess the possible anthropogenic impact on the watercourses flowing into the Baltic Sea and Puck Bay within the borders of CLP.

The research is a part of a long-term project which started in 2015 and concerns the analysis of physicochemical and microbiological parameters of water samples taken from rivers and watercourses located in the area adjacent to the CLP and remaining under significant anthropopression, especially in the summer season. Many years of observation confirm that small watercourses can also bring a huge load of pollutants to the Baltic Sea and the Puck Bay.

At the conference the results of chemical and microbiological analysis for three rivers from CLP area (Piaśnica, Czarna Wda and Karwianka) will be presented. The results from the last four years of research were analyzed in detail and the main focus was the assessment of the sanitary and ecological state of the rivers during the vacations. The scope of research included measurements of in situ parameters (temperature, conductivity, pH, dissolved oxygen). Chemical Oxygen Demand was determined using a spectrophotometer. Ion chromatography was used to determine ions concentrations (including biogenic compounds). Sanitary state of watercourses was assessed based on fecal coliforms abundance, which number was determined by the cultivation method. The determination of microbiological parameters such as: prokaryotic cell abundance expressed as total cells number (TCN), prokaryotic cell biovolume expressed as average cell volume (ACV), the prokaryotic biomass (PB) and prokaryotic cell morphotype diversity was determined using epifluorescence microscopy method.

Detailed analysis of the data revealed potential sources of pollution. It was found that in the study area, surface water quality is mostly affected by unregulated sewage management and surface runoff from nearby fields.

Algal diversity in the cascade reservoirs from the upper Yangtze River

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Algae are important taxa in riverine ecosystems and play a fundamental role in maintaining the river's structure and function. Algal diversity is considered at the levels of richness of species and of higher taxonomic ranks and as the variety of habitats algae dominate and their functional importance in the processes they mediate. The geographical distribution of algae indicates substantial differences in species richness and degree of endemism in different regions. Though many researches have been conducted on algal diversity, there is few information on the cascade reservoirs of the upper Yangtze River. In order to investigate the algal diversity in the Three Gorges Reservoir, Xiangjiaba Reservoir and Xiluodu Reservoir, investigation was carried out. The cell size spectrum, richness, abundance, habitats in the three reservoirs were compared and significant difference was found in cell size spectrum, richness, abundance and habitats. Environmental factors, such as water velocity, nutrients concentration, temperature, were the driving forces for the high degree of endemism. High degree of endemism was unrelated to overall species richness, but for some groups, such as cyanobacterium, high endemism occurred in regions of low diversity. On the other hand, results also proved the potential vulnerability of algae and algal communities influenced by water velocity/ water level fluctuation. Due to the vital role of algal diversity and the disaster consequences of algal blooms, some measurements should be taken to maintain the stability and normal seasonal succession of the algal communities.

Keywords: Algal diversity; cascade reservoir; Yangtze River

Are cyanobacteria a real threat to surface waters in cold, arid environments?

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Production of cyanotoxins by cyanobacteria is an important factor connected with widespread occurrence of cyanobacteria in surface waters as they can pose health threats to people and other organisms. Researchers discover ever new cyanotoxins with planktonic cyanobacteria as the most studied communities, but records concerning detrimental effects of toxic benthic cyanobacteria are increasing. Still not much is known about cyanobacteria and cyanotoxins from arid environments in which humans and domestic and wildlife animals face water shortages or inadequate sources of drinking water. This is especially relevant for hot and cold deserts of Central Asia. We present here results of studies from the natural environment in the cold, mountain desert of Eastern Pamir (Tajikistan) and laboratory analyses of strains isolated from this environment.

Diversity of cyanobacteria, presence of genes encoding toxin biosynthesis pathways and toxins occurrence were studied in 52 cyanobacterial mats from streams and small water bodies in highland plateau of altitude between 4000 and 5000 m a.s.l. using amplicon-based sequencing targeting the V3-V4 region of the 16S rRNA gene, toxin potential using PCR-based methods (mcy, nda, ana, sxt), and toxins by enzyme-linked immunosorbent assays (ELISAs) and liquid chromatography-tandem mass spectrometry (LC-MS/MS). Additionally, we studied 10 sampling sites in altitude gradient between 1000 and 4000 m a.s.l. In the highland plateau we identified by microscopy numerous potentially toxic taxa and genes encoding cyanotoxin biosynthesis pathways in 11 out of 52 sampling places with additional 5 out of 10 sampling places in altitude gradient. Biochemical ELISA analyses suggested presence of microcystins or anatoxins in 5 out of 52 samples while chemical analyses confirmed presence of toxins of microcystins in three samples of highland plateau and in MIB, debromoaplysiatoxin and geosmin in four samples in the altitude gradient. The analysis of two strains isolated from streams in which no toxicity genes nor cyanotoxins were detected in the natural environment exhibited debromoaplysiatoxin and microginin production in laboratory conditions.

The results of the study suggest that in an extreme environment of cold desert, despite the high diversity and biomass of cyanobacteria in microbial mats and the widespread occurrence of potentially toxic taxa cyanobacteria in seldom produce toxins and do not pose serious risk to other organisms. The reason for lack of cyanotoxicity in these extreme habitats while strains can produce some cyanotoxins in laboratory conditions is discussed.

Research funded by National Science Centre 2015/19/B/NZ9/004

Assessing water quality of ponds in lateritic tracts of eastern India across a rural-urban gradation using multivariate approach

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It is vital to understand the complex functioning of lentic water bodies that lay in transitional zones between urban and rural land class in a given watershed. This necessitates the identification of the key elements in determining the quality of water out of multiple gradients, both natural and artificial. A major part of soil in Paschim Medinipur district, West Bengal, India is primarily lateritic and faces water scarcity during summer which makes existing water resources much dependable. Ponds are surface water bodies smaller than lakes, that are common in this area, but enhanced anthropogenic actions have jeopardized their condition recently. The study aimed to compare physico-chemical parameters of selected ponds viz. contrasting study sites (n=28) across an urban-rural gradation geographically within Kangsabati river basin stretching a distance of about 50kms from the town. Samples were collected over non-monsoon phase (January to May 2020) in order to negate the dilution effect of rainfall, to assess 11 dependent variables- temperature, dissolved oxygen (DO), pH, alkalinity, salinity, hardness, electrical conductivity, total dissolved solid, nitrate, ammonium and chloride. Independent variables like coordinates, NDVI, LULC, slope and elevation of each site traversing the bank of the river were noted using GIS tools in addition to some of the ecological observations such as level of human interference and percentage of bank vegetation. The tested dataset were compared with Indian water quality standards and assigned to permissible or non-desirable classes.

DO, an important parameter, ranged 1.09-10.54 with the lowest readings from urban ponds and the highest from among the rural ones. The maximum variation was observed for TDS (29-622 ppm) and Chloride content (6.6-221.5 mg/l) whereas least variation for Nitrate (0.35-1.86 mg/l). Low TDS values belonging to rural sites (29-69ppm) might indicate the protective role of forests in checking soil erosion exhibiting water clarity. Since many of the variables followed non-Gaussian distribution, spearman rank correlation revealed that mean NDVI and elevation did exert any statistically significant impact on the dependent variables; whereas rest were positively correlated among themselves. It also turned out that mean slope lacked significant influence on any of the water quality parameters; mean elevation seemed to exert some influence on the NDVI. DO was noted to be significantly negatively correlated to chloride, conductivity, TDS and salinity. In the PCA biplot, DO showed inverse relation with water temperature while most other parameters were highly clustered. Canonical correction gave a high correlation but with low confidence.

This study may act as a lesson for the society as simple tidiness and better management practices can help in minimizing pollution. The outcome of the analysis can aid local decision-making with respect to resource utilization and future water security.

Assessment of hydrological barriers effect in river benthic fauna coupled with eDNA metabarcoding monitoring

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Anthropogenic activities alter the hydromorphological characteristics of rivers, directly affecting the ecosystems by changing community composition. River continuum interruption has been identified as one of the principal causes of longitudinal water quality variation. According to the Water Framework Directive, biological, physicochemical and hydromorphological quality elements are used to assess ecological quality. Especially for rivers, benthic macroinvertebrates are mostly used through the majority of biomonitoring programmes. Over the last decades, specific protocols have been deployed to assess the extent of hydromorphological alteration of river riparian zone. A recent advance in biomonitoring is environmental DNA (eDNA) metabarcoding, which emerges as a surrogate to traditional assessment responding to time and cost-efficiency limitations and identification. This study assesses the hydromorphological effects of two barriers (sluice and rock ramp) in a Mediterranean river (Pinios, Greece) on the structure of macroinvertebrate assemblages using traditional method coupled with eDNA metabarcoding. It further evaluates the hydromorphological alteration of the riparian zone using the "Qualitat del Bosc de Ribera" and River Habitat Survey. This study consists the first eDNA approach in biomonitoring of Pinios River and so, we attempted to: i) compare benthic macroinvertebrate assemblages of traditional and eDNA samples, ii) investigate spatial and temporal patterns of macroinvertebrate communities, and iii) assess the ecological effect of the two barriers. Thus, samplings were conducted at three stations in each barrier, one upstream and two downstream of the barrier, during the high and low flow, to test the existence of a gradient pattern. For the traditional approach, macroinvertebrate samples were collected with the semi-quantitative 3-min kick/sweep method, plus one-minute when bank vegetation existed using a D-Frame net. The same sampling procedure was applied for the eDNA approach, reducing the effort to one minute, to keep the ratio of the traditional one. Additional quantitative samples from all the available microhabitats were collected to increase the volume of the sediment eDNA to 150 cm^3. High throughput sequencing was performed on an amplified fragment of the cytochrome c oxidase subunit I (COI) gene. The results showed that the most representative taxa were Oligochaeta, Chironomidae and Crustacea with the traditional approach, while Chironomidae and Crustacea mainly contributed to the eDNA collection. There were no detected differences between seasons. However, we noticed a dispersal barrier effect only from the sluice, depending on the magnitude of the hydraulic work and operation. Our results showed that eDNA metabarcoding yields valuable information about the biodiversity of Pinios river. Further studies for eDNA methods are required, such as validation and standardization for applying indices and their modification.

Effects-based techniques for river health assessment and key toxicants identification

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Water pollution risks to human health and the environment are emerging as serious concerns worldwide. With the aim to achieve good ecological and chemical status of all European water bodies, the "European Water Framework Directive" (WFD) was enacted. Of which, bioanalytical techniques have been recognized as an important aspect. However, there are limitations to the application of bioassays directly for water quality assessment. Such approaches often fail to identify pollutants of concern, since the defined priority and monitored pollutants often fail to explain the observed toxicity. In this study, we integrated an effect-based risk assessment with a zebrafish-based investigation strategy to evaluate water sample extracts and fractions collected from the Danube. Four tiered bioassays were implemented, namely RNA-level gene expression assay, protein-level ethoxyresorufin-O-deethylase (EROD) assay, cell-level micronucleus assay and organism-level fish embryo test (FET). The results show that teratogenicity and lethality during embryonic development might be induced by molecular or cellular damages mediated by the aryl hydrocarbon receptor (AhR) -mediated activity, estrogenic activity and genotoxic activity. With the combination of high-throughput fractionation, this effect-based strategy elucidated the major responsible mixtures of each specific toxic response. In particularly, the most toxic mixture in faction F4, covering a log Kow range from 2.83 to 3.42, was composed by 12 chemicals, which were then evaluated as a designed mixture. Our study applied tiered bioassays with zebrafish to avoid interspecies differences and highlights effect-based approaches to address toxic mixtures in water samples. This strategy can be applied for large throughput screenings to support the main toxic compounds identification in water quality assessment.

Keywords: Tiered bioassays; Zebrafish; Large throughput screening; Toxicity-based mixture elucidation

Salinisation by road salt – a year-round threat to aquatic ecosystems

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Road salt (mainly NaCl) is commonly used during the winter to ensure road and pavement safety; however, increasing corrosion, and damaging footwear or roadside plants are not the only negative consequence of road salt application. Freshwater ecosystems are usually forgotten by society pollution recipient. Recent research shows that long-term application of NaCl has negative consequences on soil and the water environment.

Melting snow and rainfall are known to carry significant loads of chlorine ions through sewage systems into rivers from paved surfaces. In addition, in combination with other sources of pollution and climate change the freshwater salinisation is increasing problem for ecohydrology processes in water, which had negative consequences for water quality, biodiversity, services for society, resilience to climate change and anthropogenic impacts. We present an overview of research conducted to date regarding the potential impact of winter pollution on the aquatic ecosystem. The analysis takes an Ecohydrological approach based on the following steps:

- **Monitoring of threats** – a qualitative and quantitative process evaluation stage comprising identification of sources and levels of road salt pollution, as well as migration paths of chloride ions in the soil and water environments.
- **Cause-and-effect analysis** - assessment of the impact of road salts and their chlorides on abiotic and biotic processes in the catchment area and freshwater ecosystems.
- **Development** and optimization of methods - review of possible alternatives to the most widely-used salt, i.e. sodium chloride (NaCl).
- **System solution** - summary of the current knowledge about the influence of chlorides on aquatic ecosystems and possible directions for further actions.

This study was supported by grant No. 2018/28/C/NZ8/00235, "Impact of road salt pollution in winter on zooplankton hatching success from resting eggs." Funded by the National Science Center (Poland).

Session VI

RADOMKLIMA-PL – creation of Blue-Green City in Radom as implementation of Green Deal Strategy

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The presentation shows the preliminary assumptions, implementation and results obtained in the LIFE project in Radom on adaptation to climate change through water management as a nature based solution. The project objectives follow The New Green Deal Strategy by applying Blue and Green Infrastructure to enhance Radom resilience to climate change induced harmful results.
Adaptation to climate change is a relatively new topic in the policies of countries and cities. Undoubtedly, it is an essential element of education and awareness raising, both in administration staff and the local communities. The project has been carrying out activities aimed at adapting urban space to climate change. We are aware that opportunities for limiting negative impacts of urban climate change arise from the development of blue and green infrastructure which contributes to a more controlled rainwater management, especially in periods of time with excessive rainfall and flooding. The overall objective of the project is to increase climate resilience of Radom City by building demonstrative "green-blue infrastructure" for managing extreme storm water flows and control local flood risks. The specific objective of the project is to mainstream climate adaptation into city planning and to improve knowledge on the subject for decision-making process at local level and to rise awareness and capacity building on climate adaptation among all stakeholders of the project including local authorities (implementing measures focused on adaptation to climate change to local law, strategies and financial - investment plans), urban planners, designers, urban infrastructure management institutions, NGOs, residents – all entities taking advantage from the project results (reducing „heat island", increasing climate resilience of the city, improvement of inflowing water quality). All these actions fully obey the New Green Deal provisions guided by the idea of sustainable development and climate neutrality until 2015.

Ecohydrology for water quality, quantity and security

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The climate change indicates that sustainable, catchment water management must be characterized by a holistic and integrated approach. This approach is also a part of the ninth phase of the Intergovernmental Hydrological Programme of the UNESCO priority areas. The starting point for these activities is the concept of ecohydrology, which indicates the importance of interrelationships between ecological processes and the water cycle in the landscape, also in the city landscape. These dependencies can be used to improve the water quality in rivers, increase the local retention of rainwater or improve the microclimate in the city by using nature-based solutions.

Radom, like many cities in Poland and Europe, also faces the problems of flooding and drought alternately. The reason is a rapid surface runoff of rainwater from impermeable areas of city, which causes local flooding and unstable water flows in rivers. Rainless weather and high temperatures lead to drought and the urban heat island. Radom is the first city in Poland to take up the challenge of counteracting these changes as part of the LIFE project untitled "Adaptation to climate change through sustainable water management in the urban space of Radom" (LIFE14 CCA/PL/000101).

The aim of the project is to create an urban space with increased resistance to climate change. It is to be achieved through the use of blue-green infrastructure in the city space, that is, the planned restoration of green areas in the city, rehabilitation and adaptation of watercourses and reservoirs, and local rainwater retention. These activities are based on the ecosystem approach, also recommended by UNESCO.

As part of the project, two types of implementations were proposed to reduce the risk of city flooding from rivers firstly and as a result of intensive surface runoff from impermeable areas of city. Ecohydrological implementations carried out on the three main rivers in Radom stabilize the amount of water flowing into the city center during rainfall and ensure their availability in rainless periods. Besides, they increase biodiversity, create habitats and improve microclimate, thus mitigating the effects of climate change in the city.

The adequate water quality and quantity, especially in times of increasing climate change, ensure the security of city citizens as never before.

Mitigating of Urban Sprawl by creating a Smart Blue-Green City

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In Anthropocene the cities become the key element of reduction of anthropopressure on the biosphere, not only by reduction of energy use and pollutants emissions by switching to renewable energy sources, but also by optimising their spatial structure. This paper demonstrates that an important factor determining the city of the future's sustainability is the reduction of urban sprawl, which is degrading the ecosystem space and forested areas around the city, decreasing the agriculture, recreative potential and is increasing costs of infrastructure and emission of pollutants. That is why the proposed goal should be reversing the urban sprawl, which creates a healthy city, attractive to live in. This has to be amplified by changing the approach to urban stormwater management in face of climate change: transforming the threats of urban floods into adaptation to climate change by purification of stormwater using Ecohydrological Nature Based Solutions (Zalewski et al. 2012), and increasing water retention in the city in cascades of small lateral reservoirs (Zalewski 2020; Kiedrzyńska at al 2021). Thus by creation of a Blue-Green Network of parks connected by blue green and green corridors in a system which reduce temperature and improve air quality, adapting the city to climate change and provide an opportunity for active, healthy lifestyle and green transportation by pedestrian walkways and bicycle paths.

Water in the city – public preferences for blue infrastructure in Łódź

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Łódź is a typical post-industrial city, which arose in the XIX century based on natural resources (water and forests) necessary for the establishment of the textile industry. The industrialization process caused numerous rivers to be buried underground and become part of the sewer system, changing the character of the city. Today, city faces not only environmental problems (floods, urban heat island, low air quality) but also faces social and economic challenges like population decrease, inhabitants aging, and degradation of public space. In 2010, the City of Łódź adopted the concept of the Blue-Green Network as the basis of the life support system, restoring the great importance of the environment for the development of the city.

In line with the concept of ecohydrology, considering water as the main limiting factor of nature in the city, in our research we focused on public preferences towards different types of blue infrastructure. In the face of climate crisis, it becomes necessary to shape of multifunctional urban space in harmony with needs of citizens. The key to improving the quality of life in the city is to provide functional space for urban greenery, landscape water retention and the presence of aquatic ecosystems. Consulting with end users in the design process ensures better planning and meeting public needs.

To gather information about stakeholders needs for blue infrastructure and its services, and opportunities to increase its availability in city, we conducted surveys and asked residents to engage in the participatory urban design. Additionally, we traced ongoing discussions about blue infrastructure to check public engagement and attitudes. The presentation will show the opportunities for providing blue infrastructure, the needs of residents, and residents' views on the topic.

Session VII

Mobilizing and educating young ecohydrologists

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"The most pressing challenge, responsibility and opportunity for Europe is keeping our planet and people healthy" (EU Commission 2020 Work Programme). Water crises are already consistently listed in the top five global risks with the most substantial impact on human development, and profoundly restrict the realisation of the UN SDGs. The international community takes action with the UN "International Decade for Action – Water for Sustainable Development, 2018-2028", the UNESCO IHP strategic plan IX "Science for a Water Secure World in a Changing Environment", 2022-2029, the EU circular economy approach, the EU strategy on 'nature-based solutions and re-naturing cities' and the European Ambition "Green Deal" as the new European growth strategy. These visions require a change of mentality to be implemented successfully. University education plays a major role in educating a new generation of professionals with integrative and creative critical thinking and the necessary skills. Water problems are complex and require transdisciplinary solutions. The MAEH consortium was built to combine European expertise from different HEIs to address these water problems with an integrated approach. We join our expertise and experience to create a globally unique and innovative master programme in Applied Ecohydrology (MAEH). The programme provides student-centered and competences-oriented learning and practical field, laboratory and world of work experiences. It merges **Ecohydrology**, a water sciences sub-discipline that aims to use natural processes to increase ecosystem resilience and restore degraded ecosystems' carrying capacity, with **water engineering** for the harmonized design and use of water technologies and infrastructures, and with **integrated water management**, as the basis to successfully implement ecohydrological solutions by reconciling the needs of multiple stakeholders. The MAEH programme pursues the participation of academic, professional and institutional associated partners. We collaborate with professionals from the world of work in applied projects focusing on real-life problems. We integrate the international academic water science community by collaborating with national and global associations (as the International society for Ecohydrology - ISEH) and organizations in the field of water science (such as UNESCO International Hydrological Programme) and by including the expertise from many scientists and water professionals from around the world in the MAEH webinars. MAEH is in line with the EU EC higher education modernization agenda 2020. The programme is committed to create an innovative and high-quality programme that can be a reference in the field of water sciences within and outside of Europe. The MAEH programme links with the International Society for Ecohydrology, both contributing to the dissemination of the Ecohydrology concept and enrolling young scientists from around the world.

Students Association for Ecohydrology – Learning By Doing

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Global warming in combination with water management malpractice and overconsumption of global resources are one of the components that lead to future water scarcity. As predicted by the IPCC report for each degree of global warming, it is likely that 7% of the global population is projected to be exposed to a decrease of at least 20% of renewable water resources. Maintaining good quality of these resources is important therefore Nature-Based Solutions (NBS) that use natural processes to remove pollutants come to the rescue. In recent years, more and more scientists are interested in NBS. Many young scientists, in particular, see the enormous potential of harnessing the original properties of ecosystems as a tool to at least partially reverse the damage done by previous generations. In the face of forthcoming issues, long-term planning is needed and that is why open-minded scientists from various disciplines are necessary.

Students Association for Ecohydrology brings together young, ambitious students interested in the protection of water resources and taking care of its quality and quantity with the recognition of the problems faced by ecohydrologists today. Ecohydrology, as a transdisciplinary field, enables students to cooperate with other young scientists from various fields of hydrology, biology, ecology, chemistry, and even economics and philosophy. The activities carried out by the association give its members a chance to learn about the work on creating and introducing ecohydrological innovations from the inside out.

ENHANCEMENT OF ECOHYDROLOGICAL NATURE-BASED SOLUTIONS FOR SPECIFIC POLLUTANTS REMOVAL

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The scientific background of ecohydrology (EH) is to understand and explain interactions between ecology and hydrology, to use ecosystem processes (dual regulation) as an advanced management tools (Zalewski et al. 1997; Zalewski, 2014). Following the problem-solving character of EH, the group of Ecohydrological Nature-based Solutions (EH-NbSs) have been developed in recent years. Those can be classified as the systemic solutions (e.g. restoration of the eutrophic shallow reservoir – Zalewski, 2000, management of the river floodplain - Kiedrzyńska et al., 2015), ecological engineering solutions (e.g. Sequential Sedimentation-Biofiltration Systems – Zalewski, 2014; enhanced riparian buffer zones - Izydorczyk et al., 2013), hybrid systems (e.g. Jurczak et al., 2018) and ecohydrological biotechnologies (Zalewski, 2014).

Among the self-purification processes taking place in the aquatic ecosystems, the sorption-desorption equilibrium and biodegradation are believed to have the most significant effect (Holvoet, 2007; Kalwasińska et al., 2010). The proper management of both processes can enhance the total efficiency of Eh-NbSs for pollutant removal. However, the efficiency of both conventional and EH-NbS water purification systems decrease over time (Mitsch et al., 2012).

We propose that low mass materials (<500 kg m^{-3}), ready for exchange, may be optimal sorption substrates for EH-NbS, when demonstrating high efficiency towards P removal and possible efficiency for micropollutant removal. One of the latest concepts in EH-NbS is BioKer, a material which is developed from light expanded clay aggregates coated with exchangeable components such as calcite or biochar (Fig. 1). BioKer is six times lighter and provide 20 times higher efficiency for PO_4 removal compared to traditionally-used dolomite (Zalewski et al., 2020). The Intellectual Property Rights for BioKer are protected by patent No. P.238640 (Jarosiewicz & Zalewski, 2021).

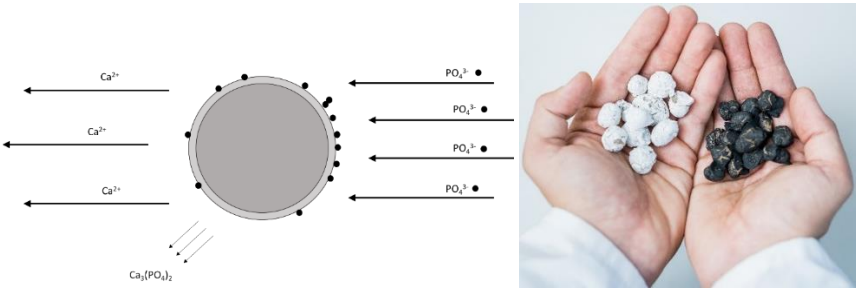

Fig. 1 BioKer can be fixed with different surface components. It can be filled with calcite for the removal of phosphates and biochar for the removal of pesticides. Left: A simplified illustration of the BioKer model of action. Right: BioKer with calcite (left hand) and biochar (right hand) (Figure modified from Jarosiewicz et al., 2022).

Influence of hydrological conditions on navigation on the Lower Vistula

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The article presents the impact of the hydrological conditions on the lower Vistula on the navigation possibilities. The hydrological regime of the lower Vistula is affected by the functioning of the Włocławek dam. Based on the data on water levels and the number of vessels locked in Włocławek in 1984–2018, the degree of exploitation of the lower Vistula waterway was determined. The conducted analysis showed that the number of units locked by the Włocławek dam varies from year to year, and shows a downward trend over the entire multiannual period. This number depended on the hydrological conditions (water levels and ice phenomena) on the lower Vistula, but also on the technical efficiency of the Włocławek lock. During a year, water transport was seasonal, with the largest number of locked units in the summer months (June-August). In the structure of water transport, freight traffic dominated over tourist traffic. The exception were the years with low water levels (mainly in the summer), when freight traffic was impossible due to too shallow depths. The reason for the low use of inland navigation in the transport structure is primarily the quality of waterways and the lack of appropriate infrastructure that will enable the transhipment of goods. In the coming years, measures are planned to adapt the waterways to transport over longer routes.

Looking for algicidal and microcystin-degrading bacteria to enhance the WBSR+CE approach in ecohydrological restoration of water ecosystems

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Anthropogenic pressure and climate change, with the consequent intensification of water eutrophication, are one of the most important challenges for water security. Cyanobacterial harmful algal blooms (cyanoHABs) are intensifying on a global scale, posing a major threat to the environment and public health, thus compromising ecosystem services and the economy. The ecohydrological approach enhances the catchment's sustainability potential by integrating water, biodiversity, ecosystem services and resilience, as well as culture heritage and education (WBSR + CE). Under this holistic approach, long-term water monitoring programs are critical for understanding the interplay between ecological interactions and hydrological processes, which is the basis for a successful mitigation strategy. However, as far as the cyanoHABs are concerned, current monitoring techniques focus on abiotic data collection and overlook biotic players, thereby missing essential information for implementing nature-based solutions. Considering ecosystem inhabitants as cyanoHABs regulators, it could be suggested the use of bloom-associated bacteria as mitigation tools. Our studies showed that cyanobacteria-dominated scums may contain algicidal bacteria capable of removing some of the most pernicious and common cyanobacterial species, such as the genera *Microcystis* and *Aphanizomenon*. In particular, we have observed that the bacterial strain SU7S0818, identified as *Morganella morganii* (99.51% similarity) according 16S rRNA gene, was capable of producing a combination of algicidal substances, and therefore stands out as a promising bacterium for the biological control of cyanoHABs. Likewise, co-existing with cyanoHABs are a wide variety of bacteria capable of degrading microcystins (MC), one of the most toxic hepatotoxins produced by cyanobacteria in freshwater. The identification of indigenous bacteria with such capabilities during water monitoring and their subsequent isolation would facilitate the design of strategies to exploit them as ecosystem management tools. In fact, the number of MC-degrading bacteria isolated from the natural environment is increasing, which is boosting biological systems as an alternative or complement to physicochemical processes during drinking water treatment. Thus, it is evident how understanding the role of biota in ecosystem functioning reveals significant information for problem solving, and therefore, bacteria associated with cyanoHABs should be considered as a key element in monitoring programs and in the ecohydrological restoration of aquatic ecosystems.

Research funded: National Science Centre 2019/33/B/NZ8/02093 "ALGICYDY"

The influence of physico-chemical parameters on fish and pelican mortalities in Lake Natron Ramsar site

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Lake Natron Ramsar Site (LNRS) is a recognized Ramsar Site and Important Bird and Biodiversity Area. It is a breeding site for 75% of the global population of Lesser flamingo (*Phoeniconaias minor)*. Water quality changes can affect the plankton composition and diversity and thus affect ecosystem abundance. Water quality assessment at LNRS was conducted after reported alkaline fish (*Alcolapia sp.)* and pelican (*Pelecanus onocrotalus)* mortalities. The aim of this study was therefore to investigate the role of physico-chemical parameters on LNRS. This cross-sectional study involved water sample, socio-economic data collection and laboratory analysis. Water samples were collected from five sampling sites at LNRS during wet and dry season. Physico-chemical parameters including pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), ammonium, electrical conductivity, total dissolved solids, nitrates and phosphates were assessed. Additionally, plankton composition and abundance were analyzed to investigate the cause of reported mortalities. Observation and interview methods were used to assess the anthropogenic activities taking place along inlet rivers. BOD, COD, ammonium and pH values were higher against the Tanzania Environmental Management Act and WHO recommended values for freshwater, thus resulting to low DO levels. There were no zooplankton or phytoplankton colonies observed from sampled water. The study observed anthropogenic activities such as unsustainable agriculture, deforestation, overgrazing at LNRS. The reported physico-chemical changes could be due to anthropogenic activities and climate change at LNRS which caused reported fish and pelican mortalities. The study therefore proposes watershed management using nature-based solutions for LNRS ecosystem sustainability.

Keyword: Lake Natron Ramsar Site, Lesser flamingo, Water quality, anthropogenic activities, Nature-based solutions

The Future of Ecohydrology in Africa: Mobilizing Youth for Water Resources Management and Ecohydrological Transformation

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Water resources rivers are among the global anthropogenic impacted ecosystem. The degradation of rivers, coastal areas, wetlands, floodplains, and catchments has currently been exacerbated jointly by anthropogenic influence and the impact of climate change. Population pressure poses a special threat via pollution, catchment, watershed degradation, and impervious surfaces. As a is a systemic solution, Ecohydrology deploys ecosystem properties to enhance the resilience and carrying capacity of water ecosystems. Some of the common techniques include Constructed Wetlands, Sedimentation-Biofiltration systems, and Blue-Green Infrastructure for water pollution control and climate change adaptation respectively. SED-BIO was able to reduce Nitrogen (73%-NO3-,70%-NO2-, 99%-NH4-) and up to 52% of Phosphorus in Jelonek Lake-Poland. Sequential Biofiltration Systems removed Nitrogen, Phosphorus, Organic matter, and Minerals by 76, 93, 36, and 67% respectively along Asela Lake-Ethiopia. Other ecohydrological application includes the use of macroinvertebrates to monitor the health of rivers and trace cumulative long-term effect. To increase the resilience and adaptation to urban climate change, Blue-Green Infrastructures were constructed in Radom City-Poland to reduce the urban heat effect, cut off the extent of greenhouse gases from the local scale, and reduce the risk of city flooding. The revealed performance needs to be transformed and implemented in other parts to rescue water resources from anthropogenic degradation. In growing continents like Africa, such transformation and thus the future of Ecohydrology lies within youth which forms over 50% of the population. Meaningful youth mobilization, engagement, and support through vertical and horizontal integration are required to promote and upscale the performance. With the practical applied ecohydrology techniques, the formation of the African Young Ecohydrologist Association is of great consideration to bring about transformation from molecular to catchment scale, and monitoring and reporting to long term actions. Together with the International Society for Ecohydrology, this youth coalition will further the work of UNESCO canters and chairs to promote and implement Ecohydrology in Africa for a secure and sustainable water resources management, the actionable future of Ecohydrology foreseen.

Session VIII

Ecohydrological Approach to Restore Ancestral *"Cochas* and *Tajamares"* of Pisaca Hill: Water Sowing and Harvesting in Catacocha, Loja, Ecuador

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In the hydrographic micro-basin of the *San Pedro Mártir* stream, in the Loja province in southern Ecuador, a water, soil and vegetation management system has been carried out since pre-Inca times, in which the *cochas* and the cutwaters or *tajamares* are constituted essential elements. These small water pounds are designed for Water Sowing and Harvesting (WS&H), i.e., to let water infiltrate into the subsoil and aquifers on high elevations during the rainy season, and to make use of the slow circulation of water in the subsurface before capturing it from rivers and springs on lower altitudes during the dry season. The achieved discharge of water flow contributes to the maintenance of vegetation, increases biodiversity, and makes water available for different uses. This work presents main meteorological, hydrological and ecohydrological characteristics of the San Pedro Mártir catchment, and presents work on restoring ancestral knowledge that was subsequently used for recovery and replication of *cochas* and *tajamares*. In addition, a comparative analysis of the distribution of different types of vegetation is presented in which we evaluate the effects of WS&H on the biota by comparing satellite data of the area before and after the interventions. The restoration of this ancestral WS&H system, in which we counted with support of various local and international institutions and worked in close collaboration with the Autonomous Decentralized Government of the *Paltas cantón* (municipality), has improved the quality of life and ecological conditions in the surroundings of Catacocha city. Hence, this work presents a successful example of dialogue between scientific and local ecological knowledge, which has been recently recognized by UNESCO's IHP as one of the few Ecohydrology Demonstration Sites in the world, the first one in Ecuador.

Analyzing Ecohydrology as Paradigm Shift in Conservation for Sustainable Flow of Ecosystem Services along Kihansi River Catchment, Tanzania

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Mountains ecosystems are the water-towers and source of majority of rivers across the globe. Apart from being the source of water for ecological and socio-economic benefits, mountain ecosystems are cherished and celebrated for having forest catchments as habitats for wildlife, sources of ecosystem services (ES), hydropower generation and important tourist destinations for income generation and local communities' livelihoods. However, despite their ecological and economic significance, their potential in offering ecosystem services have not been fully researched and, therefore, not given high conservation priorities. Furthermore, financing the conservation of mountain ecosystems sustainable flow of ES has been the major challenge in many, countries and estimating the values of ES from river catchment is critical for sustainable management decisions. To address the contemporary conservation challenges, it is high time to apply nature-based solutions instead of the former conventional approaches for conservation. The study was conducted in Kihansi River Catchment (KRC) along Udzungwa Mountains in Tanzania to identify and estimate the types and value of ES offered by KRC for the purpose of establishing a base for an innovative and sustainable financing management.

Household questionnaires were used to collect data. Informal interviews, closed and open meeting and site visits were also used. Time series data on average daily and base flows between 1992 and 2017were collected from Rufiji Basin Water Board. While data collected using household questionnaires were analyzed by using STATA and SPSS software, time series data on water flows were subjected to Mann-Kendall Test Statistic. The study indicated that the value of ES in the KRC makes a total economic of USD 306,092,882,927 of which99.6% of this value comes from water. With respect to carbon sequestration, the capacity was estimated at USD 306,092,882,927 USD if 5% is taxed from carbon market price. In terms of ecology, the KRC hosts biodiversity some of which are endemic and critically endangered including the Kihansi Spray Toad and Kihansi Wild Coffee. Water from KRC generates electricity at Kihansi Hydropower Plant which contributes enormously to the county's economy. Average daily flows for Kihansi River for a period 1992 to 2017 indicated that, the minimum flow was 4.74 m^3/s while the maximum was 63.96 m^3/s. Base flow contribution to the total water yield into the reservoir was higher during the 1990 as compared to the year 2016. Water yield has changed by 13% from 1990 to 2016, implying a decrease rate of 0.73% per year. Surface runoff increased from 359 mm in 1990 to 547 mm in 2016. The average flow in the former period was 15.55 m^3/s while in the later period was 14.22 m^3/s indicating a decrease of 1.33 m^3/s. The decrease in base flow associated with an increase in surface runoff suggested the impact of land use and land cover change on water flows. The decrease in base flow and average daily flow was found to be associated with the loss of vegetation cover and resulted in less infiltration

during the rainy season and hence less recharge. Therefore, findings from this study form the basis for the application of new conservation approach (ecohydrology) for sustainable management of the KRC which advocate on the use of ecological approaches in nature conservation.

Keywords: *Water catchment, Ecosystem services, Ecohydrology, Mountain ecosystems, Tanzania*

To Ally Technology, Nature and Society for successful urban water management

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Cities challenge sustainable water management with number of issues. Firstly, accumulation of assets shifts the understanding of environmental risk reduction from maintenance of resilient urban system towards hard engineering and strong top down control. Secondly, variety of views over functions and organization of the city and values of its nature make consensus over management actions difficult. Thirdly, use of regulatory services of nature as management tool requires good quality ecosystems, wisely considered in urban fabrics what, due to legacies and competition over land uses.

Harvesting from the experiences of a number of projects carried in the sites of Long-Term Ecosystem Research network and capitalizing on long-term socio-ecohydrological research three IHP EH demos – representing both networks – launched under the umbrella of JPI Water a common project ATENAS. For over 2.5 year Helsinki, Lyon and Łódź have continued work targeted at upscaling of ecohydrological solutions and elaborate a know-how on how to deal with the three urban water management challenges. We established a framework for inclusive, participatory NBS planning, developed tools to understand societal needs over urban spaces, valued variety of greenery types in the cities, and implemented EH solutions with the prospect for their upscaling.

Simultaneously ATENAS helped us to define bottlenecks to the process and initiated number of dialogues on potential solutions tackling economic, institutional, ecological and social domains.

Ecosystem based approach as a priority to save Lake Tana, Ethiopia

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This paper reviews the management of the Lake Tana environment using ecosystem based approach that comprehensively addresses all environmental resources within the context of a living system. Lake Tana and its environment is known for its rich biodiversity and registered as the largest UNESCO Biosphere reserve in the country. The lake has global, national and local significances. As a major growth corridor of the country, it provides 20%, 400 MW, and 1.2 million hectare for tourism revenue, hydroelectric power, and irrigable floodplain, respectively. The lake environment such as the lake water, floodplain and riverine wetlands, inflowing river mouths, and lake shore area natural forests are threatened from habitat alteration including shoreline and River bank buffer zone degradation, point and non-point pollution, siltation, over exploitation of resources like excessive withdrawal of both Stream and lake water, and invasive alien species like water hyacinth (Eichornia crassipes), Azolla, and Ipomoea carnea. Consequences of these threats include fish breeding ground and wildlife habitat loss, water quality detoriaration and algal blooming, the loss of wetlands and macrophyte decline, and to end with poor economic development for sustainability. Several processes unlikely to have contributed to the shift from clear to turbid Conditions, including long- term changes in external input of sediments, chemical fertilizers and urban wastes, and fluctuations in water level.

An ecosystem-based management undergoing in Lake Tana environment include riparian buffer delineation and restoration, excessive plant nutrient reduction using echo-hydrologic approach (wetland enhancement, food web manipulation to reduce internal loading), create diversified livelihood activities such as addition of values to wetland products, promote conservation agriculture using organic fertilizer, animal forage and fruit production in the buffer farming system to increase income of the local community. An ecosystem approach is generally viewed as a succession of approaches to managing human uses and abuses of natural resources. Therefore, sustainability means that the off take from the renewable resource that is being exploited should not be greater than the sustainable yield defined by ecologists; the harvest rates should be within the capacity for regeneration of the resource; and waste emission rates should be within the capacity of the local ecosystem to absorb and assimilate within natural bio-geochemical cycles.

Performance evaluation of a model constructed river diversion wetland for improving quality of water of an inland river in Kumasi, Ghana

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The world is faced with an increasing need to improve quality of freshwater bodies such as streams and rivers due to impacts of human activities. Constructed river diversion wetlands have been recognized as potential ecohydrological systemic solution for meeting quality requirements of flowing freshwater bodies. In this study, the performance of a model constructed river diversion wetland for improving quality of water from River Wiwi located in Kumasi under the influence of different flow regimes and vegetation densities was evaluated. The wetland comprised three cells planted with *Typha angustifolia* based on a planting density of 4, 8 and 12 stems per m^2 and the fourth cell was without any plant as a control. The performance of the wetland cells were evaluated through hydrological and water quality monitoring, and estimation of pollutant removal efficiencies based on the different flow regimes used in the study. Reduction in turbidity levels were lowest under the high flow regime and ranged from 2.68 % to 84.98 %, while for the low flow regime it ranged from 44.43 % to 96.46 %. Biochemical Oxygen Demand (BOD) removal was highest (68.53 %) in the cell with the highest planting density and lowest (6.44 %) in the control. Total Nitrogen (TN) removal efficiencies were in the range of 48.3 – 88.27 % for the planted cells and 11.18 – 29.21 % for the control. The removal efficiencies of Total Phosphorus (TP) were low for all the wetland cells and ranged between 6.11 and 41.69 % at the outlets. The removal efficiencies of Faecal Coliforms (FC) were found to be high and ranged between 33.53 and 54.93 % at the mid-sections while at the outlets it was between 69.76 and 97.45 %. The removal efficiencies of metal parameters also ranged from -11.04 to 85 % for Arsenic, 22.61 to 72.33 % for Cadmium and 35.65 to 98.13 % for Lead. Both flow regime and vegetation planting density were found to have significant effects on the removal efficiencies of the wetland cells. The results showed that greater pollutant removals were achieved mostly under low flow regime than moderate and high flow regimes. Additionally, pollutant removal efficiencies of the planted cells were higher at all sections of the wetland cells than the unplanted cell (control). The highest efficiency values were recorded in cell with the highest planting density and the trend was consistent for all parameters and flow regimes.

Strengthening Sustainable Ecosystem Services and Water Resources Management Based on Ecohydrology Implementation

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Water resource availability and quality support not only well-being and human health but also provide essential ecosystem functions of wetlands, lakes, rivers, and coastal. Anthropogenic activities and climate change are mostly sources of high pressure on these natural resources and tend to increase water ecosystem deterioration and environmental degradation. The aquatic ecosystem contamination may have a substantial impact on human beings and their environment related to goods and services. Unintegrated, monodisciplinary, and sectoral approaches often be a hindrance to managing and overcoming completely water-related problems. Ecohydrology is defined as a transdisciplinary science that deals with the dynamics of biology and/or ecology and the interaction of hydrological processes in various conditions of temporal, spatial, and human life practices around its environment. This article aims to show the ecohydrology concept in a way to strengthen sustainable ecosystem services and water resource management. The implementation of ecohydrology in Saguling demonstration sites was reported. The results showed that this approach may be used as an alternative solution to improve and restore water ecosystem functions and services. However, it is important to be noted that political and government support, economic valuation, as well as local society involvement should be taken into consideration in order to get sustainable and effective solutions for water resources management.

Keywords: ecosystem services, ecohydrology demosite, water quality, water resources

Figure 1. Saguling Ecohydrology demonstration site in the upper Citarum watershed

Posters

The goals, development and future of ecohydrology

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More than one billion people in the world have problems with access to clean, safe water. This is due to, among other things, anthropogenic pollution emitted into the environment, deteriorating the quality of water and increasing the risk of its eutrophication. Furthermore, climate change is exacerbating these negative phenomena and making access to the basic substance needed for the existence of living organisms - water - even more difficult. Consequently, there is a strong need to analyze and de facto re-build strategies for the management of environmental resources, especially water. Scientists from all over the world have been looking for answers to how, by limiting costly engineering solutions, to improve the availability of water, its quality and also to take advantage of natural solutions developed by nature. Based on these needs, a new scientific discipline - ecohydrology - has emerged. It proposes to use the interaction of water and biota to exploit ecosystem processes as a new tool in water and environmental management (Zalewski 2005).

When we analyze the number of scientific publications with the keyword "ecohydrology" we can see a clear trend in the development of this discipline and an increasing interest in it by scientists from all over the world. It should also be stressed that the future for the further development of ecohydrology lies with young scientists and the promotion of ecohydrological solutions in society and among various levels of policy makers.

Nutrient transfer in river-lake system under human pressure

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Watercourses of all sized are subject to multiple pressures in human-altered watersheds. Agriculture, urbanization, peatland drainage in river catchment as well as hydrotechnical structures including weirs and culverts affect nutrient concentrations. Increased nitrogen (N) and phosphorus (P) content influence water quality in the receiver of watercourses, while its transformations in the lake, both natural and induced by human actions like restoration, exert an impact on the nutrient content in outflowing river. These issues were studied in Lake Trzesiecko, which is a receiver of main river Nizica and few small streams, flowing from both agricultural and urbanized catchment. The main inflow drains mainly agricultural catchment with drainaged peatlands, while streams collects water from rural and urbanized areas. The lake is dammed at the outflow of Nizica river, and the river section within city limits is channelized. Nutrient concentrations and water flow velocity were measured in 2016 and 2020 in spring, summer and autumn, to assess nutrient loads supplying the lake as well as outflowing from the lake. The loads were related to watershed management and river stream alterations, and were also used to calculate the balance of nutrients for Lake Trzesiecko.

In 2016 mean total N load supplying the lake was 113 kg d^{-1}, decreasing to 108 kg d^{-1} at the outflow, indicating scarce accumulation of nitrogen in the reservoir. Mean total P load inflowing to the lake was 1.4 kg d^{-1}, increasing to 2.1 kg d^{-1} at the outflow of Nizica river, as a result of internal P loading from lake sediments. Main inflow was responsible for over 50% of inflowing N loads throughout the research period, but in case of P its role decreased in summer on the benefit of smaller streams flowing from urbanized part of the catchment. In 2020, mean total N load supplying the lake was significantly reduced to 35 kg d^{-1}, as well as the outflowing N load – 32 kg d^{-1}. Mean total P load inflowing to the reservoir increased to 1.6 kg d^{-1}, while at the outflow it was slightly lower than in 2016 – 2 kg d^{-1}. Other tendencies were similar as in 2016, indicating the structuring role of catchment management for river/stream water quality. Improvement in both water quality (lower nutrient concentrations) as well as in habitat conditions (appearance of macrophytes typical for slightly eutrophic rivers) in the main inflow of Nizica river affected total external loads from catchment. In smaller streams they remained on the same level as in 2016, this exerting a stronger impact on lake and outflowing river water quality. Therefore, solutions aiming at the reduction of loads coming from two streams were implemented by means of small-scale systems of sedimentation and biofiltration, created by gabions filled with crushed dolomite rocks and macrophytes. Additional actions shall be undertaken in the urbanized catchment to improve hydromorphological conditions of small streams.

Natural or anthropogenic? Use of $\delta^{18}O\text{-}PO_4$ tracer to determine the origin of phosphates in eutrophic waters

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Phosphorus, like nitrogen, is one of the crucial bioelements limiting the biomass multiplication. The excess of phosphorus in soil is favorable for agriculture and forestry, but in surficial waters causes increased eutrophication, which is destructive for water quality and for ecological balance. In the last decades, anthropogenic eutrophication has become one of the greatest environmental problems, therefore studies which can improve the assessment of water quality are very important.
Isotopic composition of oxygen in phosphates ($\delta^{18}O\text{-}PO_4$), the most common form of P in lithosphere and hydrosphere, could be used as a tracer of phosphorus cycling between the biomass, soils, waters and sediments. Recently, the $\delta^{18}O\text{-}PO_4$ analysis are widely used for identifying different phosphate sources and better understanding P cycling in marine and freshwater research (ie. McLaughlin *et al*., 2004; Young *et al.*, 2009; Paytan *et al.*, 2017; Gooddy *et al.*, 2018).
Our studies are focused on selected areas of the Vistula and Bug interfluve, in which the main groundwater reservoir feeding the river is developed by cracked formations of the Maastricht and Tertiary developed in the form of: opokas, margles, chalk, gaizes, limestones, and sands (Michalczyk & Wilgat, 1998). Average orthophosphates concentration in water extracts from collected bedrocks was determined at the level 0.5 mg/dm^3, whereas for the nearest spring waters was found 0.3-0.7 mg/dm^3, which may suggest a high content of phosphates derived from leaching of natural phosphorus minerals from sedimentary rocks in rivers fed by these springs. We will present the preliminary results of our studies, in which isotopic studies of $\delta^{18}O\text{-}PO_4$ were used to determine the origin of phosphates and to estimate the impact of phosphates derived from individual point and non-point sources in the total pool of P in analyzed surface waters.
These studies are founded by the Polish National Science Centre (grant No. UMO-2020/37/B/ST10/01994)

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The Pilica River's oxbow lakes and their environmental significance

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Oxbow lakes are common in Polish and European landscapes. They exist as natural formations around meandering rivers, and sometimes as intentionally formed reservoirs due to watercourse management. Despite the fact that we are already aware of their environmental services and are implementing different measures of protection in their regions, they have not piqued the interest of scientists. Furthermore, due to biogenic pollution, ongoing hydrotechnical activities on rivers, and increased drought frequency, such structures are disappearing from our regions, often without our knowledge, emphasizing the importance of changing the trend in the amount of research and activities aimed at knowledge and the conscious exploitation of oxbow lakes
This review shows the amount of publications in Poland on oxbow lakes and meandering rivers, with a focus on the Pilica River. According to field investigations, the Pilica valley has around 200 oxbow lakes with varying biological characteristics. The most important functions they perform and the threats to their existence were outlined.

This work is an outcome of the LIFE Pilica Basin CTRL integrated project: Implementation of River Basin Management Plan in the Vistula basin on the example of Pilica river catchment (LIFE19 IPE/PL/000005), which has been supported by the LIFE+ Environment Policy and Governance Programme, and the Polish National Fund for Environmental Protection and Water Management.

Impact of road salt pollution on zooplankton organisms inhabiting urban water reservoirs

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Road salt – typically sodium chloride – is a substance commonly used for road maintenance during winter months. Sodium chloride is cheap, yet effective solution for deicing that contributes to road safety. However, this practice has its drawbacks. Higher concentrations of chlorides in surface waters can be harmful to various freshwater organisms, including zooplankton. The aim of this study was to determine the relationship between chloride ion concentration and the density and species composition of zooplankton in four urban watersheds in relation to winter weather conditions.
The study site consisted of four urban reservoirs located in Lodz city: Arturówek Górny (control reservoir), Wasiak Reservoir, Julianów Górny and Zgierska Reservoir. The study was conducted in hydrological years 2019 (average winter), 2020 (mild winter) and 2021 (harsh winter). Sodium and chloride ions were analysed in the water and bottom sediments samples using ion chromatography. Zooplankton samples were collected during the vegetative season, using a zooplankton net with 50 µm mesh size. They were analysed using a Sedgewick-Rafter chamber and a Nikon microscope. Statistical analyses were performed using Statistica 13 software.
We observed significant differences in the chloride concentrations between years ($p = 0.000$), reservoirs ($p = 0.000$), as well as for the interaction year*reservoir ($p = 0.024$). The lowest concentrations were observed in year 2020 (mild winter), the highest concentrations in 2021 (harsh winter). Among the reservoirs, the lowest concentrations were observed in the control reservoir – Arturówek Górny. We observed significant differences in zooplankton density between years ($p = 0.003$) and reservoirs ($p = 0.000$). Zooplankton density in 2019 was significantly higher than in other years. The highest density was observed in Zgierska Reservoir and the lowest density was observed in Wasiak Reservoir and Julianów Górny.
Our research showed that in Wasiak Reservoir, Julianów Górny and Zgierska Reservoir concentrations of chlorides depended on winter conditions – the highest concentrations were observed during the coldest winter. We confirmed the role of Arturówek Górny as a control reservoir – at this site concentrations of chlorides maintained on the lowest level and did not depend on winter conditions. In the reservoirs with highest chloride concentrations (Wasiak, Julianów Górny), the density of zooplankton was the lowest. However, it could be also affected by other factors (size of the reservoirs/the availability of sunlight). Density of zooplankton was the highest in the Zgierska Reservoir. It suggest that there must be some aspects at play (e.g. food availability, especially organic matter) that are beneficial for zooplankton, therefore making it possible for zooplankton to thrive despite higher salinity.

Research was conducted within the project number 2018/28/C/NZ8/00235 financed by National Science Centre within the call SONATINA2 entitled “Influence of the road salt pollution on the hatching success of zooplankton resting eggs.”

Aquaculture technologies for effective utilization of water resources

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Water quality and availability are becoming one of Central European aquaculture's main limiting factors. Freshwater resources are under the sway of such factors as water demand-driven socio-economic activities and climate-governed seasonality in the water supply. Therefore the essential part of freshwater aquaculture development are solutions enabling effective utilization of water resources.

One of the main challenges the fish industry faces is to minimize wastewater production and enhance its purification, which helps to upgrade the ecological and economic efficiency of traditional fishery production. In the Institute of Ichthyobiology and Aquaculture Polish Academy of Sciences in Gołysz modern concepts and technological solutions at the technical and biological levels are tested in order to increase freshwater aquaculture sustainability. In pond aquaculture, the unutilized nutrients are reused by primary producers and passed on through all levels of the pond trophic web. As a result, a considerable share of biogenic elements is returned into natural fish feed. Therefore, fish ponds are able to accumulate and utilize effectively high amounts of nutrients. As practice shows, there are efficient ways to control the utilization of most of the resources used in aquaculture and generated wastes.

One of the possible courses of action is the concentration and intensification of fishing production on smaller facilities inside the farms, while maintaining the remaining ponds with their current nature of production. In such a system, the intensive part of the farm provides the dominant part of the production, expressed both in the fish biomass and the production value. At the same time, such a concept allows for a potential reduction in the intensity of production in the rest of the pond farm, even to the extensive level, which allows to reduce water usage and to preserve or even improve the natural values of fishponds.

River floodplain restoration in harmony with society: case study Kochanovice

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Our endeavour is a restoration of watercourses and their floodplains according to requirements for landscape protection, ecological stability and enhancing their ecosystem services. This means particularly restoration watercourses and their floodplains and support of species in their natural habitats. These aims are also social demands that however are conditioned by further education of the whole society.

Hereby we present a floodplain of Podhura River following a complex of 4 ponds in forested part of Protected Landscape Areas (IUCN Category V). The floodplain is mainly a grassland in part covered by unsuitable woods (spruce) and with agricultural drainage system in place. The river Podhura is a channelized, deepened and straightened brook with riverbed enforced by concrete blocks. The whole of the floodplain and the complex of ponds is Special Area of Conservation "Kochanovicke rybniky a tune" (CZ 0533696, with the protected species of Triturus cristatus and Bombina bombina). Initially, therewere created some pools for protected species of amphibians. This however proved to be insufficient, and the hydrological regime required complex solution. Now we are at the beginning of a project to completely disable the drainage system by cutting the drainage pipes and their filling with clay (in 204 places). Part of the project is also a construction of new near natural channel of the Podhura River and creating of 13 pools within the floodplain. Remnants of old buildings will also be removed, and visitor infrastructure components will be installed.

It is a paradox that such restoration project in protected area faces several limitations and issues. While within cities, mainly in Prague, where such limitations would be expected, complex restorations are done basically as public requests where the quality of ecosystem services matters.

Tourist and cycling trails pass through the Podhura River locality and considering the protection of the locality the aim is rather to inform and guide visitors. Although the land withing the floodplain is state-owned (and managed by the Nature Conservation Agency) it was necessary to reimburse the owner of the remnants of the riverbed enforcement. Another challenge is to design appropriate channel for the river while the inflow is fully controlled by the operation of the complex of ponds. The complex is placed on the watershed line, so it is possible to discharge to neighboring catchment. The permission for the use of water and rules of operation set the minimum residual flow, but at the same time the channel capacity is required to contain discharge when emptying the ponds. Such conditions were the base for water authority permission proceeding.

We believe that a monitoring following the restoration will prove our assumptions of hydrological regime regeneration to support species population and their habitats and water retention within the catchment. We also believe that this exposed locality will help to further improve public environmental awareness.

Important aspects of plant water balance in terms of the risk of drought in the changing climate

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In recent years, moisture has become a limiting factor in all agro-climatic zones of the world (IPCC, 2022), and the problem of drought resistance is a determining factor in ensuring sustainable agricultural development (FAO, 2021). Insufficient water supply of plants leads to changes in cell water exchange and, as a consequence, to the violation of metabolic functions of the plant organism. The role of water is important in shaping the structure and properties of biological systems, it largely determines their state under stress. Therefore, an important aspect for maintaining and restoring the quality of the environment is the study of water balance of plants in climate change. Factors that affect the water balance in plants, it is necessary to include the moisture content in the soil, the temperature of the soil and air, relative humidity. Among the forms of adaptation of plants to the adverse effects of these factors, the regulation of water regime of plants occupies a special place, as it determines the intensity of important physiological processes - photosynthesis, respiration, intake, transport and redistribution of mineral nutrients, etc. (Raza et al., 2019).
To assess the water status of the plant is of particular importance to study the processes of self-regulation aimed at eliminating water imbalance of the plant, which may occur due to violation of the concentration gradient of water and water vapor in the system: soil – plant – atmosphere (Sun et al., 2020). This is very often due to the uneven distribution of precipitation and rising air temperatures during atmospheric and soil droughts. The reactions of plants to these factors are very complex and depend on the depth and duration of their action, the stage of growth and development of plants. Water loss by the plant organism initiates regulatory processes that cause changes in gene expression and metabolism of plants, which leads to the formation of adaptive potential of plants in arid conditions of growth and increase their drought resistance (Sun et al., 2020). Modern research is focused on studying the response of plants to the action of stress factors at the molecular level (Hura et al., 2022). Groups of genes have been identified that are expressed in response to loss of water content induced by water stress. The expression of such genes is necessary to ensure plant resistance to stress and the formation of adaptive potential. Therefore, a detailed study of the water balance of plants is needed to reduce crop losses and maintain sustainable agricultural development in the changing climate caused by drought. This is necessary in terms of targeted impact on plant water metabolism to ensure optimal cell homeostasis, which will increase the realization of adaptive potential and drought resistance of plants and will be important for food security.

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Microbial and chemical quality assessment of the small rivers entering the Puck Bay

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Due to its location, Puck Bay is an area particularly vulnerable to pollution of anthropogenic origin. The aim of the study was to assess the water quality of small watercourses entering the inner part of the Puck Bay.

The research is a part of a long-term project which started in 2015 and concerns the analysis of physicochemical and microbiological parameters of water samples taken from rivers and watercourses located in the area adjacent to the CLP and remaining under significant anthropopression, especially in the summer season.

At the conference the results of chemical and microbiological analyses of 10 rivers and canals at their estuaries located on the western shore of the internal Puck Bay will be presented. The results from the last four years of research were analyzed in detail and the main focus was the assessment of the sanitary and ecological state of the watercourses during the vacations. The scope of research included measurements of in situ parameters (temperature, conductivity, pH, dissolved oxygen). Chemical Oxygen Demand was determined using a spectrophotometer. Ion chromatography was used to determine ions concentrations (including biogenic compounds). Sanitary state of watercourses was assessed based on fecal coliforms abundance, which number was determined by the cultivation method. The determination of microbiological parameters such as: prokaryotic cell abundance expressed as total cells number (TCN), prokaryotic cell biovolume expressed as average cell volume (ACV), the prokaryotic biomass (PB) and prokaryotic cell morphotype diversity was determined using epifluorescence microscopy method.

Based on the obtained results, it was found that small watercourses may carry a notable load of anthropogenic pollution and thus affect the environment of Puck Bay. The results clearly indicate the need for quality monitoring in the rivers and canals in the Coastal Landscape Park, flowing into Puck Bay. The research showed that also smaller watercourses may have an impact on the coastal waters' state, and thus on the Baltic Sea water quality.

Does the functional diversity can be a tool used to diagnose the pattern of benthic invertebrate communities in coastal lakes?

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We based our study on biological trait analysis (BTA), which provides a link between the distribution and biological characteristics of species. Our research investigates differences in the structure and functional diversity of benthic fauna in terms of seven biological traits (mobility, habitat, feeding type, habitat modification, body form, body size and feeding apparatus) in nine south Baltic coastal lakes whose salinity ranged from 0.1 to 7.3 PSU. Multivariate statistical analysis of biological traits produced similar results to those obtained in traditional species-based analysis, but with more distinct differences between lakes. The results obtained showed that Baltic coastal lakes are inhabited by similar species of benthic fauna, but that certain biological traits occur with different frequencies. We therefore identified features that may affect the functioning of coastal lakes with a relatively narrow salinity gradient (0.1–7.3 PSU). It seems to confirm the possibility of using BTA methods (with a preference for presence-absence BTA) to determine key characteristics that are helpful for understanding the functioning of aquatic ecosystems. The results may provide a basis for further research on changes in the functional diversity of lakes along the southern coast of the Baltic Sea, particularly in view of climate change due to their characteristics (small, shallow, less resilient).

Accumulation properties of plants associated with streams and peatbogs of spring areas

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Spring areas are characterized by a rich diversity of plant species. The species growing on the banks and bottoms of streams uptake and accumulate in their shoots nutrients, coming mainly from spring waters and, to a lesser extent, from soils. Plants growing in peat bogs benefit to a much greater extent from components leached from peat soils than from spring waters, which is reflected in their chemical composition.

The aim of the study was to compare the accumulation properties of plants directly related to streams and peat bogs of spring areas in northern Poland and to select species with the highest accumulation potential in relation to macro- and microcomponents. The research was carried out in Northern Poland, on the forested spring area of the Kamienna river, which is a tributary of the Słupia river. The plants were collected from 26 sites near streams and from 7 sites located directly at piezometers installed on peat bogs. In the course of the 4-year study, in total 24 plant species (288 samples) directly related to streams and 17 plant species (204 samples) from peat bogs were analysed. The plants were sampled three times in each growing season (May, July, September), the water and soil samples were collected on a monthly basis. To compare the accumulation properties of plants, the following methods were used: Annual Components Analysis (ANE) and Principal Components Analysis (PCA) after normalised varimax rotation.

Plants associated with streams accumulated from 1617.9 to 4799.1 mmol $_{(+)}\cdot kg^{-1}$, and plants growing in peat bogs from 2068.2 to 3828.7 mmol $_{(+)} \cdot kg^{-1}$ of the analysed components, with micro-components constituting 0.6-5.5% and 0.47-1.1%, respectively. Among the species directly related to the streams, the largest amounts of accumulated macro- and micro-components were found in the shoots of *Chrysosplenium alternifolium, Cardamine amara, Veronica beccabunga* and *Solanum dulcamara.* In the case of plants associated with peatbogs, *Urtica dioica, Caltha palustris, Circaea lutetiana* and *Geranium robertianum* showed outstanding accumulation abilities. In addition, it was found that peatbog species showed, on average, better supply in N, Ca, Zn, Sr and Ni than vegetation growing along the banks of streams. The vegetation associated with streams was on average more abundant in P, K, Mg, Mn, Fe, Cu and Al than peat species. Statistically significant differences between the accumulation capacities of the compared groups of plants concerned Zn and Mn ($p<0.05$) and Fe and Al ($p<0.001$). The principal components method was used to distinguish four components explaining a total of 61.04% of variance. The first factor (FC1) grouped Ca, Sr, FC2 (Fe, Al), FC3 (N, P, K), and FC4 (Zn, Ni), characterized by high, positive values of factor loadings. The categorized scatter of points between the isolated factors confirmed statistically significant accumulation differences between the compared groups of plants.

Ecohydrological solutions as effective methods of removing heavy metals from surface waters

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Heavy metals are a group of xenobiotic compounds that constitute a serious threat to freshwater and marine ecosystems. The sources emitting the largest amounts of them include i.a. agriculture, industry, transport, urbanization and wastewater discharges from treatment plants. High pollution of the Baltic Sea is mainly due to the fact that it is almost completely closed sea, and the catchment area covers nine highly developed agricultural and industrial countries.

The aim of the research is to conduct analysis of the pollution of the Baltic Sea with heavy metals flowing from the catchment area and to present examples of their effective removal from the environment, including the use of ecohydrological biotechnologies.

The main routes of heavy metal emission to the Baltic Sea are river runoff and atmospheric deposition. In the case of the inflow of the pollutant with river waters, it is the result of the inflow of water volume and pollutant concentrations. The average annual inflow of river waters to the Baltic Sea is 14 000 m^3.

In total, in 2013-2017, up to 2149.2 tons of heavy metals were transported to the Baltic Sea, including: 112 tons of cadmium, 23.2 tons of mercury and 2014 tons of lead, of which 80% of the cadmium, 33.2% of mercury and 59% of the lead load came from river waters (HELCOM, 2021). It gives an average of $1.12x10^{-5}$ tons of cadmium, $9.60x10^{-7}$ tons of lead and $1.48\ x10^{-4}$ tons of mercury released from river runoff per year/per km^2 of the catchment area. Moreover, in the same years, a total of 13.99 tons of these metals were delivered to the Baltic from point sources.

As a result of atmospheric deposition, in the years 2013-2018, 25.9 tons of cadmium and 17.3 tons of mercury were sent into the Baltic Sea, and in 2013-2017 it was 812 tons of lead (HELCOM, 2021). In 2018 the Baltic Sea received an average of $2.62x10^{-6}$ tons of cadmium and $1.75x10^{-6}$ tons of mercury per 1 km^2 of the catchment area.

Although the release of heavy metals is regulated by stringent regulations, they are still detected in the marine environment. Nevertheless, in order to permanently eliminate these compounds from the environment, it is necessary not only to thoroughly understand the scale of pollution and analyze the sources of their emissions, but also to develop effective methods for the remediation of polluted waters (Kiedrzyńska et al. 2021) and wastewater (Kiedrzyńska et al. 2017). These methods are based on biofiltration and bioremediation processes as well as phytotechnologies. The use of microorganisms and plants in the remediation of polluted waters has a high potential for immobilization and elimination of heavy metals such as nickel, chromium, copper, cadmium, zinc, mercury and lead. Additionally, the effectiveness demonstrated by them means that their use is in line with the current policy of the European Commission, the *European Green Deal* and the *Baltic Sea Action Plan*, which aimed at improving the condition of surface and marine waters.

Influence of deflectors on the rate and speed of river restoration

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Restoring natural fluvial processes to river ecosystems is becoming an increasingly important element of water management. Such activities are carried out mainly for natural reasons, but are also of considerable economic importance. The natural aspect concerns the creation of friendly living conditions and the development of natural biocoenoses and an overall increase in biodiversity. The restoration of river ecosystems is particularly important at a time when water resources are decreasing all over the world, especially in Poland.

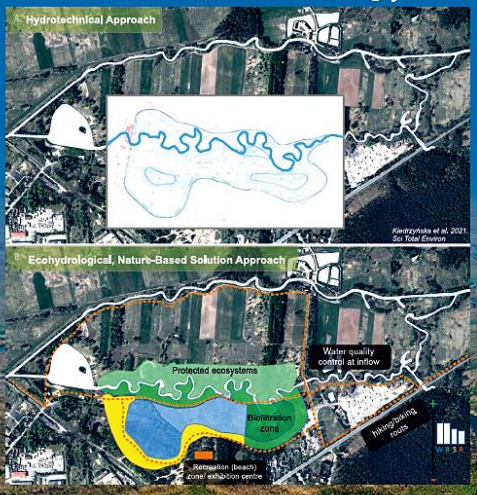
In order to improve the ecological status of watercourses a comprehensive approach should be taken. Due to the scale of the undertaking, it seems that deflectors may be the best solution. These are simple constructions of seminatural character built in most cases of wood, wicker and stones. Their simple structure ensures ease and speed of construction and at the same time is relatively cheap. Their varied design ensures that they can be built for almost any type of watercourse.

This poster presents the results of long-term measurements including studies of quantitative and qualitative variability of flora species found in riverbeds. The estuary section of the river Flint, which is a representative river in its size class, was specially selected for the study. The measurements date back to 2005 and include maintenance work carried out on the entire section in 2011. In 2018, wicker deflectors were installed on the selected section of the Flint. Conducting measurements on the control sections made it possible to determine the degree and dynamics of progressive changes in the river in a natural way and to compare them with the changes observed in the section with installed deflectors. An increase was observed in The research results showed a significant influence of the introduced structures on improvement of the quality of aquatic ecosystems.

ECOHYDROLOGY
FOR WATER SECURITY

5th International Symposium of Healthy Rivers and Sustainable Water Resources Management

LATERAL RESERVOIR
for purifying river from polutants
(e.g. protecting against toxic algal blooms)
and providing WBSRC potential
(W - water, B - biodiversity, S - ecosystem services, R - resilience , C - cultural heritage)



SEQUENTIONAL SEDIMENTATION - BIOFILTRATION SYSTEM
for purifying river from polutants
(e.g. nitrogen and phosphorus)