VIENNAWATERCONFERENCES2023

21.-25. August 2023,
Vienna, Austria

CONFERENCE ABSTRACT BOOK

WORLDS LARGE RIVERS CONFERENCE VIENNA–AUSTRIA
21–25 AUGUST 2023

5TH INTERNATIONAL CONFERENCE ON THE STATUS AND FUTURE OF THE WORLDS LARGE RIVERS

BOKU
UNIVERSITY OF NATURAL RESOURCES AND LIFE SCIENCES, VIENNA

Abstract Overview

This Document shall provide you with an overview of all presented abstracts at the World’s Large Rivers Conference 2023 in Vienna, Austria.
The abstracts are sorted by topics in the order in which they have been presented during the sessions. You can search for keywords in the title or last names of the authors by using **CTRL + F**.
To view the abstract, please, press **CTRL** and click on the PDF-Hyperlink in the right column.

Topic I	Hydrology, Hydraulics and Hydraulic Impacts
Topic II	Sediment Transport and River Morphology
Topic III	River Pollution, Ecology and Restoration
Topic IV	Integrated River Basin Management
Topic V	Special Session
Topic VI	Others

I – HYDROLOGY, HYDRAULICS AND HYDRAULIC IMPACTS

Natural and human-induced impacts on the Diyala-Sirwan River basin, Iraq	**Hayder Al Hudaib**, Katalin Bene, Richard Ray	22
Characteristics analysis of non-stationary water level in Huangpu River	**Zhihui Liu**, Shuguang Liu	23
What future for the Medjerda, and its hydraulic facilities?	**Jean Albergel**, Yadh Zahar	24
Climate change and water resources management in the Murray-Darling Basin	**Francis Chiew**	25
Climate Change Impact on the River Runoff of Nizhnekamskoe watershed	**Kseniia Kortunova**, Yury Motovilov, Tatiana Fashchevskaya	26
Impact of climate change and land-use changes in Senegal river.	**Mame Henriette Astou Sambou**, Stefan Liersch, Hagen Koch, Jean Albergel	27
Effects of climate change on the Usumacinta river	**Yaridalia Ramirez Abundis**, Maritza Liliana Arganis Juárez, Ramon Dominguez Mora	28
Ribeira River influence on the Cananéia-Iguape estuarine-lagoon complex using modelling	Ana Maria Haytsmann, Samuel H. Yang, Vitor G. Chiozzhi, Joseph Harari, **Elisabete S. Braga**	29

II – SEDIMENT TRANSPORT AND RIVER MORPHOLOGY		
Title	**Authors**	**Page**
Sensitivity analyses of river morphodynamic parameters affected by climate change	**Fabian Beimowski**, Regina Patzwahl	30
Phosphorus Background in Marine Sediments Under La Plata River Influence	Glaucia Bueno Benedetti Berbel, **Elisabete S. Braga**	31
Abrasion and sediment management: Experimental study in a rotating drum	**Philipp Gmeiner**, Marcel Liedermann, Sebastian Pessenlehner, Christoph Hauer, Roland Kaitna, Helmut Habersack	32
Downstream transport of the suspended matter along the Middle Daugava	**Dāvis Gruberts**, Juris Soms	33
Long-term fine sediment deposition in Vienna's Danube floodplain before channelization	**Severin Hohensinner**, Sabine Grupe, Gerhard Klasz, Thomas Payer	34
Bank Erosion of the Guadalquivir Estuary	**Juan Pedro Martín-Vide**, Francisco Núñez-González, Carles Ferrer-Boix, Garcia-Barroso, Bejarano	35
Sensitivity of the Jamuna-Brahmaputra River Morphology to Multidecadal Hydroclimate Variability	**Andrew Nelson**, Maminul Haque Sarker, Ashley Dudill, Ruhul Amin	36
Numerical-modelling and earth-observations for dynamic management of Old Brahmaputra offtake	**Amgad Omer**, Asheque Mahmud,Mohamed Yossef, Farhana Akhter Kamal, Jakia Akter, Erik Mosselman	37
Sediment transport of Narva River	**Marina Shmakova**	38
Evolving Columbia River Basin sediment loads, late 1800s-2020	David Jay, **Margaret McKeon,** Heida Diefenderfer, Stefan Talke	39
Sediment balance and transport in the Five-country Biosphere Reserve Mura-Drava-Danube	**Roman Dunst**, Mario Klösch, Ulrich Schwarz, Kerstin Böck, Helmut Habersack	40

GIS Assessment of Sediment Pathways Within Lena River Catchment	**Sergey** Chalov, Oleg Yermolaev, Y Shynbergenov, Kirill Maltsev	41
Toxic Prymnesium Parvum Blooms During Fish Kills in Oder River	Agnieszka Napiórkowska-Krzebietke, Hanna Mazur-Marzec, Elisabeth Varga, Krystyna Kalinowska, Konrad Stawecki	42
Modeling Refuge Habitats for Rejuvenation of The Odra River	Piotr Parasiewicz, Shubham Wagh, Katarzyna Suska, Andrzej Kapusta	43

III – RIVER POLLUTION, ECOLOGY AND RESTORATION		
Title	**Authors**	**Page**
Euphrates River Water Quality by Remote Sensing and GIS	**Jasim Ali**	44
Anthropogenic Debris Monitoring using a Littertrap at the Rhine River	**Katharina Hoereth**, Nina Gnann, Leandra Hamann, Niklas Prophet, Nicolas Schweigert	45
Monitoring coastal riverine litter accumulations in the Tisza River Basin	**David Attila Molnar**, András Kristóf Málnás, Miklós Gyalai Korpos, Máté Cserép	46
Chemical monitoring at the river rhine – tomorrow is yesterday?	**Lars Duester**, Daniel Heintz	47
Heavy metal contamination in floodplain area along the Mekong River,Laos.	**Thipphachanh Souliyavong**, Kim Kyoung-Woong	48
Modelling the concentration of antibiotics in the global river system	**Bernhard Lehner**, Heloisa Ehalt Macedo, Jim Nicell, Usman Khan, Eili Klein, Günther Grill	49
Spatial distribution of anthropogenic radionuclides in the soil-freshwater ecosystem	**Lydia Bondareva**	50
Rhine salmon population threatened by multiple hurdles along their migration	**Jacco Van Rijssel**, Erwin Winter, Joep de Leeuw	51
Large-scale eDNA metabarcoding survey of Danube fish communities	**Paul Meulenbroek**, Thomas Hein, Tibor Erős, Alice Valentini, Michael Schabuss, Horst Zornig, Mirjana Lenhardt, Ladislav Pekarik, Pauline Jean, Tony Dejan, Andrea Funk, Didier Pont	52

Restoring nursery habitats for fishes in the lower River Rhine	**Leo Nagelkerke,** Twan Stoffers, Antonie Buijse	53
Longitudinal connectivity changes and migration patterns of potamodromous fish	**Johannes Kowal**, Michael Grohmann, Andrea Funk, Günther Unfer, Gertrud Haidvogl, Thomas Hein	54
Long-term fish community shifts and rehabilitation of Rhine and Meuse	**Jean Albergel,** Yadh Zahar	55
Habitat shifts highlight the importance of heterogeneity in fish nurseries	**Tom Buijse**, Antonie Buijse, Leopold Nagelkerke	56
Monitoring: A technical approach for long-term management of river restoration and conservation	**Jennifer Lisa Insupp**, Vanessa Berger, Daniel Dalton, Michael Jungmeier	57
Seasonal plankton-dynamics in a free-flowing section of the Ob River	Liubov V. Yanygina, Olga S. Burmistrova, Anton V. Kotovshchikov, **Martin Schletterer**	58
Planning and Execution of Sensor Fish Deployments at Xayaburi HPP	**Maria Collins**, Thanasak Poomchaivej, Wayne Robinson, Lee Baumgartner, Pedro Romero-Gomez	59
Microplastic retention by lagoons surrounded by vegetation in wetland areas	Mirco Mancini, **Teresa Serra**, Jordi Colomer, Luca Solari	60
Hydro-geomorphic perspectives on microplastic transport in the Rhine River	**David Range**, Thomas Hoffmann	61
Vertical distribution of riverine macro- and mesoplastics	**Stephanie Oswald**, Frank Collas	62

Inventory and outlook of sediment research in the Rhine Catchment	**Michael Krapesch**, Mario Klösch, Wilfried ten Brinke, Helmut Habersack	72
Development of City River Management Platform in the Smart City	**Bon Hyun Koo**, Taeyoung Ham, Eunjeong Lee, Kyucheoul Shim	73
Shallow-Water Habitat in a Highly Altered River-Estuary	David Jay, **William Templeton**, Amy Borde, Heida Diefenderfer, Stefan Talke	74
The Dutch river system: tipping points in supply and demand	**Anna Kosters**, Bart Maas, Nathalie Asselman	75
Trajectories and future of the anthropized Seine River	**Laurence Lestel**, Michel Meybeck, Catherine Carré	76
Mapping capacity, demand and pressures for hydrological services in Canada	**Camille Ouellet Dallaire**, Bernhard Lehner, Elena Bennett	77
Non-Stationary and Frequency Analysis of Extreme Rainfall in regional watersheds	**Yuting Jin**, Shuguang Liu, Zhengzheng Zhou, Qi Zhuang	78
Protection systems for bedload management in torrents	**Lisa Puschmann**, Markus Moser	79
Pressure and Sensitivity Analysis of the 15 Largest River Basins	**Ahmet Göktas**, Muhammet Azlak	80
A Multi-Objective Multi-Reservoir Study using Particle Swarm Optimization under Hedging	**Kanishk Saxena**, Nagesh Kumar D., S.K. Satheesh	81

Lessons learned from evaluating Australia's famous proposed inter-basin diversion scheme	**Cuan Petheram**, Arthur Read, Justin Hughes, Chris Stokes	82
Sustainable management of the navigability of large natural rivers	**Erik Mosselman,** Calvin Creech, Jean-Michel Hiver, Nils Huber	83
Water sharing between India and Pakistan: losses suffered because IWT.	**Jorgen Fredsoe**	84
Flood Management Application Example in Large River Basin	**Gülşah Cakir Heikal**, Erkan Eminoğlu, Filiz Malkoç, Serkan Buhan, Yasemin Yılmaz, Ali İhsan Akbaş, Özden Ertürk Gazel, Mehmet Uğur Yıldırım	85
Synthetic Series and Optimization: Hydropower Dams of the Grijalva River	Valencia Rosa, Ramó Domínguez,. Maritza Liliana Arganis Juarez, Eduardo Juan, **Alejandro Mendoza**, Rosalva Mendoza, Eliseo Carrizosa, Faustino De Luna	86

V – Special Sessions		
Title	**Authors**	**Page**
Assessing The Reach-Scale Channel Pattern of Rivers in Albania	Bestar Cekrezi, Marta Crivellaro, Flamur Bajrami, Klodian Brahushaj, Klodian Skrame, Guido Zolezzi	87
The 5-country UNESCO Biosphere Reserve Mura-Drava-Danube	Arno Mohl, Kerstin Böck	88
The Upper Neretva – How Europe`S Pristine Rivers Are Dam(N)Ed	Sarah Höfler, Thomas Friedrich, Kurt Pinter, Wolfram Graf, Steven Weiss	89
The Shkumbin River, Albania: Hydromorphological Evolution Phases	Flamur Bajrami, Marta Crivellaro, Bestar Cekrezi, Klodian Skrame, Guido Zolezzi	90
The Global Biodiversity Framework's Restoration Target and South-Eastern Europe's Rivers	Theresa Schiller, Michele Thieme	91
Joint Fact Finding for River Restoration with REACT and D-Ecoimpact	Valesca Harezlak, Marc Weeber, Mijke Van Oorschot	92
Defining Environmental Flows for Ramganga with Habitat Simulation Model Mesohabsim	Piotr Parasiewicz, Stefan Schmutz, Michael McClain, Jyoti Nale, J. Anthony Johnson, Amiya K. Sahoo, Rebecca Tharme, Ashvani Gosain, Luc Verelst	93

VI - Others		
Title	**Authors**	**Page**
Impacts of Harmful Algae on Macroinvertebrates in The Oder River	Andrzej Kapusta, Arkadiusz Duda, Maja Prusińska, Sylwia Jarmołowicz, Agnieszka Napiórkowska-Krzebietke, Jakub Pyka, Konrad Stawecki, Grzegorz Wiszniewski	94
The Odra River – an Inventory After a Fish Kill	Jacek Szlakowski, Wojciech Prekurat, Paweł Buras, Janusz Ligięza	95
Hyperspectral Flights on The Oder River During an Ecological Disaster	Katarzyna Suska, Janusz Ligięza, Wojciech Prekurat, Dominik Kopeć, Jan Niedzielko	96
Minerals as Provenance Indicator of Sediments Transport by Diyala River	Fouad Al-kaabi, Manal Al-Ubaidi, Esraa Muhammad Ali I	97
Hydrodynamic Modeling of Oil Spill in Coastal Areas: Azemmour Estuary	Nisrine Iouzzi, Mehdi Haffane, Mohamed Chagdali, Mouldi Ben Meftah, Michele Mossa	98
Fish Migratory Behaviour in Proximity to the Iron Gate Dams	Marija Smederevac-Lalić, Gorčin Cvijanović, Mirjana Lenhardt, Dušan Nikolić, Miroslav Nikčević, Stefan Hont, Marian Paraschiv, Marian Iani, Rachel Paterson, Eva Thorstad, Finn Økland	99
Flood Wave Propagation along Euphrates River Due to Haditha Dambreak	Ali Fakhri, Lubna Imad	100
The Effect of Mosul Dam Break along the Tigris River	Hanan Al-Timemy, Hasan Khattawi, Ali Fakhri	101
Derivating Toxicity Indicators for Heavy Metal Vulnerability in Aquatic Organisms	Jinhee Park, Sang Don Kim	102

Improvement of Automated Hydrological Observation Technology and Application	Sheng-Hsueh Yang, Wen-Shang Chou, I-YU Wu, Jia-Lin Ma, Yi-Ping Wu,. Chia-Wen Lee, Keh-Chia Yeh, Cheng-Wei Lee	103
Lena Delta Climate-Driven Changes of Sediment Transport and Channel Dynamics	Sergey Chalov, Kristina Prokopieva	104
New Insights in The Coupled Danube – Black Sea System	Jürg Bloesch, Bernd Cyffka, Thomas Hein, Cristina Sandu, Nike Sommerwerk	105

Varieties of Non-Stationary Tides in Tidal Rivers

David Jay[1], Matt Lobo[1], Pascal Matte[1], Steve Dykstra[1], Sylvia Innocenti[1], Stefan Talke[1]
[1]Portland State University, Portland, United States.
[2]Princeton University, Princeton, United States.
[3]Environment and Climate Change Canada, Meteorological Res. Division, Montreal, Canada.

Tidal rivers are a major component of river ecosystems, sometimes stretching for 100s of kilometers. In this domain tides and flow are inversely correlated, because flow damps tides, making them strongly non-stationary. Because tidal analyses procedures typically assume that tides are stationary, choice of analysis method is important. We investigate tides in two system, the Lower Columbia River Estuary (LCRE) and the San Francisco Bay Delta (SFBD), where fluctuating river flow and management practices cause tides to be highly variable in space and time. The specific situations investigated are: a) the effect on tides of long and short spring freshets in the LCRE; and b) the impact of an essentially instantaneous closing a barrier in the SFBD that limits salinity intrusion during very low-flow periods. Three different tidal packages are compared: a) Utide, a conventional harmonic analysis (HA) program; b) NS_Tide, which builds variable river flow into the basic functions used to represent tidal constituents; and c) CWT_Multi, a wavelet analysis approach that uses multiple scale filters at tidal frequencies and the linearity of wavelets to separate constituents and maximize temporal resolution. All three assume that tidal frequencies are known, but different assumptions are used to maximize frequency response. Also, two residual re-samplings (moving-block and semi-parametric bootstraps) for estimating the variability of tidal regression parameters are compared in a Monte Carlo experiment. CWT_Multi is the least prone of the methods to instability, and provides results that are comparable or better to the other two methods, as judged by uncertainty levels and ability to reproduce artificial data with known frequency content. The short freshet and the instantaneous barrier closing yield especially interesting results, with ambiguities as to what is physical and what is a result of methodological assumptions. These arise from different causes in the three methods, and physical reasoning is required to determine the correct answer. This result reinforces the first rule of non-stationary tidal analysis—view each problem with a variety of tools. Overall, all three methods have their uses, and each has different strengths and weaknesses.

Flood Hydrology and River Recovery in Eastern Australia

Amir Mohammad Arash[1], Kirstie Fryirs[1], Timothy J. Ralph[1]
[1]Macquarie University, North Ryde, Australia.

The geomorphic and vegetative structure of rivers in coastal catchments of New South Wales (NSW) have been highly disturbed since European colonization. However, since the late 1980s, nearly 55% of rivers in these catchments have undergone a significant ‘re-greening’ and geomorphic recovery with significant changes to the roughness of these rivers. In this study, approximately 7,000 available one-hour interval hydrographs are used at 117 gauges on 45 study rivers (17 of 20 catchments) to assess the changes in flood hydrology over time. A range of indicators of hydrograph shape and flood attenuation are used to quantify changes in flood hydrology for all in-channel fresh, high flow (bank full), and overbank floods from the early-20th Century to present. The results indicate that significant changes in flood hydrology, especially in some large rivers, are occurring. These changes in flood hydrology at individual stations produce hydrographs that are less peaked, more negatively skewed with a slower rate of rise, and are more platykurtic. Changes from upstream-to-downstream include an increase in peak-to-peak travel time, a lower flow wave celerity and attenuation of flood peaks. These findings help identify whether a signal of hydrological flood mitigation is emerging, with implications for the development of nature-based river and flood management strategies.

Uncertainty Analysis, Quantification in HEC-RAS Results for Probabilistic Hydraulic Simulation

Hossien Riahi-madvar[1]
[1]Vali-e-Asr university of Rafsanjan, Rafsanjan, Iran.

Introduction: The uncertainties in hydraulic modelling of large rivers are integral part of hydrological and hydraulic models, and this drawback restricts their applicability in river engineering projects. In this paper, the uncertainties in rating curve, stage, top water width, stream power, shear stress, Froude number and velocity are analyzed and quantified by Monte-Carlo Simulation (MCS) combined with HEC-RAS model.

Methodology: As a case study, a 105 km reach of Great Karoon River in Iran is used and model is calibrated using two year daily river flow and stage levels. A computational control module is developed and combined with computational core of HEC-RAS to perform MCS automatically, by developing a subprogram that create and modifies the input files of HEC-RAS, run it automatically based on prior distributions of n Manning, and analysis the results of HEC-RAS model for uncertainty quantitation. In order to refine proper MCS from non-proper ones, the NSE>0.75 index is used to objectively sample n Manning from uncertainty analysis and results evaluated by 5 and 95% uncertainty bounds for high and low flows and quantified by 95PPU and d-factor indices.

Results and Discussion: The results in 105 km length of Karoon River reveals high level of uncertainties with d-factor greater than 1 up to 11 in peak discharge 3000 and mean daily discharge 457 m^3/s. Using exclusion rule NSE>0.75 reduced the uncertainty of d-factor in results of rating curve, stage, top water width, stream power, shear stress, Froude number and velocity. The d-factor of water stage reduced from 2 to 0.07 in peak discharge, and from 0.96 to 0.02 in low flows. These uncertainty reductions in top width of water were 2.5 to 0.19 in peak discharge and 1.3 to 0.078 in average flows of Karoon River. The highest uncertainty of HEC-RAS model results observed in water velocity and Froude number with di-factor 10.85 and 7.44 in peak discharge respectively. The spectral responses of hydraulic parameters, indicate that although the HEC-RAS model produced high uncertainty values, especially in the complex geometry of Karoon River, but these uncertainties dos not deviate the hydraulic patterns of river flow in the study reach.

Conclusion: The uncertainty results revealed high level of latent uncertainties in HEC-RAS model results and probabilistic analysis of model results is required for river simulation of large rivers such as Karoon River to provide certain and reliable results. The presented methodology and framework of the current study that uses automatic control and automation of HEC-RAS, strengths the modeling capability of one-dimensional river flows for probabilistic analysis and automatic calibration of this mode.

GRDC: Global Archive for River Discharge Data

Claudia Färber[1], Ulrich Looser[1], Henning Plessow[1], Thomas Recknagel[1]
[1]Global Runoff Data Centre (GRDC), Federal Institute of Hydrology (BfG), Koblenz, Germany.

River systems are an integral part of the global water cycle, which are linked to many processes on local, regional and global scales. Terrestrial monitoring of rivers is fundamental for the sustainable management of available water resources on regional or catchment scale.
The Global Runoff Data Centre (GRDC) operates under the auspices of the World Meteorological Organization (WMO) at the German Federal Institute of Hydrology (BfG). It holds the most substantive collection of quality assured river discharge data on global scale. Established in 1988 to support the research on global and climate change and integrated water resources management, GRDC has been a key partner in a number of data collection and data management projects. It connects national hydrological and hydrometeorological services, the primary providers of river discharge data and associated metadata, and the scientific research community utilizing this unique data collection.
Currently, the Global Runoff Database contains river discharge data collected at daily or monthly intervals from more than 10,000 stations in 160 countries. This adds up to around 490,000 station-years with an average record length of 46 years. GRDC archives international data of up to 200 years old, fostering multinational and global long-term hydrological studies. As a trustworthy source for runoff data, GRDC has been integrated into the WMO Catalogue for Climate Data, supporting the scientific community to analyze global climate trends and assess environmental impacts and risks. National Hydrological Services are encouraged to supply suitable river discharge data and associated station metadata for publication through GRDC (http://grdc.bafg.de/).

Nitrogen Retention of a Large Tropical River - a Mass Balance Approach

Md Ataul Gani[1,2,4], Gretchen M. Gettel[1], Anne van Dam[1], Johannes van der Kwast[3], Kenneth Irvine[1,2], Michael E. McClain[1]

[1]Department of Water Resources and Ecosystems, IHE Delft Institute for Water Education, Delft, Netherlands.

[2]Aquatic Ecology and Water Quality Management Group, Department of Environmental Sciences, Wageningen University and Research, Wageningen, Netherlands.

[3]Department of Land and Water Management, IHE Delft Institute for Water Education, Delft, Netherlands.

[4]Department of Botany, Jagannath University, Dhaka, Bangladesh.

Nitrogen retention by rivers is a global concern due to increased coastal pollution. In the present study, a mass balance approach was used over a 50 km river reach, the Padma River in Bangladesh, to estimate the nitrogen retention from 2019 to 2020. The study reach is the confluence of the world's two big rivers, the Ganges and the Brahmaputra and carries about a two-thirds nutrient load of the country. Based on the monthly nitrogen concentration and discharge measurements, the relationship between concentration and discharge was determined, and daily nitrogen flux was calculated from the inflow and the outflows of the reach. The potential denitrification rate (PDR) was measured from the water column of the river. Water travel time from inflow to outflows and discharge data were used to upscale PDR for the reach. The monthly measurements showed a substantial variation in nitrogen retention; maximum retention occurred in the monsoon months. The retention estimation was mainly influenced by the water retention (flooding flood plain areas), partly by the particulate and dissolved nitrogen flux. The estimated PDR showed that the contribution was 42% to the influx, other than monsoon. This finding reveals that the nitrogen retention mechanisms varied seasonally in the study river. During monsoon, river discharge increases the surface area to volume ratio of the primary and secondary channels, which regulates nitrogen retention. Besides the monsoon season, the increased surface area of terrestrial geomorphic units increased the PDR, and less water flow enhanced retention time to interact with in-channel geomorphic units; thus, nitrogen was exported through the outflows resulting in negative retention. The study provides the current status of the river as a site for nitrogen transport to the coastal areas of the country and shows the role of hydrology and geomorphology in regulating nitrogen retention.

Multi-Disciplinary Assessment of Five Large Unregulated Rivers in Northern Australia

Cuan Petheram[1], Ian Watson[2], Justin Hughes[3], Seonaid Philip[4], Chris Stokes[2], Danial Stratford[3], Carmel Pollino[3], Marcus Barber[4]
[1]CSIRO, Hobart, Australia.
[2]CSIRO, Townsville, Australia.
[3]CSIRO, Canberra, Australia.
[4]CSIRO, Brisbane, Australia.

Northern Australia—the area north of the Tropic of Capricorn—comprises more than 3 million km² or 40% of Australia’s land mass but remains relatively undeveloped and sparsely populated, accommodating around 1.25 million people (5% of the total Australian population) of which Indigenous people comprise a large and increasing proportion. The north of Australia is globally unique in that it contains the largest intact tracts of tropical savannas in the world and is home to many of the world's longest unimpeded rivers.

Recent focus on the development of regional Australia and on the shortage of water and climate-based threats to food and fiber production in the nation’s south have redirected attention towards the possible use of northern land and water resources. However, most of northern Australia’s land and water resources and physical and socio-cultural environments have not been mapped or understood in sufficient detail to support reliable resource allocation, regional planning, investment decisions, or to provide policy settings that can support such decisions.

Since 2012 CSIRO, Australia’s national science agency, has been undertaking large (>100 people) multi-disciplinary bio-physical and socio-economic assessments across northern Australia. This presentation provides a comparative evaluation of five large unregulated rivers in northern Australia, which collectively have an area of over 400,000 km², an area 12% larger than Germany but with only 0.01% of the population.

Key challenges in evaluating these river systems include the sparsity of data and that the landscape is vast and many areas are remote. These latter two points make the acquisition of new on-ground data particularly challenging. To address these challenges CSIRO developed novel methods that blended sparse but targeted on-ground measurements, remotely sensed data and numerical and statistical modelling methods. These included the first applications of methods such as statistically based digital soil mapping for land suitability evaluation at scale, infrastructure alignment and cost optimization models (e.g., Damsite model) and novel integrated web-based river system and ecological response models. A desirable feature of the methods and models employed by the assessments was being able to quantify the uncertainty in predictions providing estimates of uncertainty enables decision makers to determine for themselves the importance of uncertainty in informing their decisions.

It was found that the five river systems, the Fitzroy, Roper, Flinders, Gilbert and Mitchell rivers, and their physical and socio-cultural environments and the nature of potential development opportunities and accompanying risks varied considerably, highlighting that northern Australia is not one homogenous area and that to properly understand the scale and nature of development opportunities - and the risks that attend them - a detailed understanding of catchment resources is necessary.

Optimizing Water Levels of Natural Lakes in Flood Risk Management

Max Preiml[1], Christoph Klingler[2], Hubert Holzmann[2], Helmut Habersack[1]
[1]Insitute of Hydraulic Engineering and River Research, University of Natural Resources and Life Sciences Vienna, Vienna, Austria.
[2]Institute of Hydrology and Water Management, University of Natural Resources and Life Sciences Vienna, Vienna, Austria.

Water level control of natural lakes plays an important role in sustainable water management and integrated flood risk management. Natural lakes contribute to flood risk reduction by water retention and flood peak reduction. Lake outlet facilities such as weirs allow to actively control water level and retention. This opens up water management optimization possibilities, but also may lead to conflicts between different stakeholders. At lake Mondsee, in Austria, there is a demand to analyses the current weir operation regulation.
The impact of lake retention on flood risk is investigated by answering three questions. (1) What is the importance of forecasting models in flood risk management of natural lakes? (2) What is the influence of lake retention on flood control? (3) Which weir operation rule can be used to balance the interests of multiple stakeholders?
The basis for answering these questions is a hydrological water balance model on daily values for the period 1978-2018 as well as a hydraulic (physical and numerical) model for detailed mapping of the lake outlet reach to the weir. In an analytical process the data of a stakeholder survey are interrelated with modelling results and boundaries of an improved flood risk management at lake Mondsee are outlined.
An event-related lowering of the lake based on forecast data was investigated. An additional release over 3 days prior to the peak of the 2013 flood event would have reduced the maximum lake water level. The lead time for reliable meteorological forecasts in this area is however about 24 hours and releasing high discharges off the lake would result in acceleration of flood risk downstream.
Seasonal lowering of the mean water level was examined. This measure would provide an additional retention volume. Based on the event history and the hydraulic boundary conditions of the lake outlet during the 2013 flood event no significant reduction in discharge or maximum lake water level was observed. Seasonal lowering of the water level might intensify dry periods as data from summer 2018 demonstrates.
Numerical and physical modelling of the lake outlet reach shows a limited hydraulic capacity. The weir overflow is reduced by morphological alterations. Flood risk management can only be improved by increasing the water conveyance off the lake. Morphological measure in combination with adaptions of the weir operation rule are proposed. First calculations show that a peak water level reduction of around 30 cm during the 2013 flood event was achieved without increasing the flood risk downstream. Modelling outputs are currently evaluated and rated by incorporating the data from the stakeholder analysis. Result is expected to outlay the scheme of an optimized weir operation rule.

Natural and Human-Induced Impacts on The Diyala-Sirwan River Basin, Iraq

Hayder Al Hudaib[1], Katalin Bene[1], Richard Ray[2]
[1]Széchenyi István University, Department of Transport Infrastructure and Water Resources Engineering, Győr, Hungary.
[2]Széchenyi István University, Department of Structural and Geotechnical Engineering, Győr, Hungary.

In recent decades' population growth, socioeconomic, urbanization trends, and agricultural development have increased water resources demand by all stakeholders. This has led to the required storage of more water by the expansion of hydraulic control structures through cascades of multi-purpose da Climate change has increased successive years of droughts and floods. Consequently, its impact and anthropogenic changes have caused non-stationarity in hydrology, leading to changes in the natural river flow regime, especially in transboundary river basins. The current study objectives implement to develop a framework for evaluating the river's hydrological alteration impacts by multiple potential hazards for natural and human-induced processes. The methodology includes assessing the hydrological regime through multiple -hydrological indicators beside drought hazard maps for various seasons and scenarios with the aid of geographic information system techniques. Furthermore, separating the climate variability impacts from the anthropogenic development. The study includes the hydrological analysis of historical streamflow and hydro-meteorological evaluation for the Diyala-Sirwan international river basin between "Iraq-Iran", which represents the third-largest tributary of the Tigris River system. The main Diyala River has three catchment areas; the Upper from the sources in Iran to Darbandikhan Dam inside Iraq, the Intermediate region between Darbandikhan and Hemrin Dam, and the Lower extends to the confluence with the Tigris River south of Baghdad with a total catchment area of about 33000 Square Kilometers. The main Diyala River and tributaries flow regime was impacted by both natural and human-induced developments through cascade dams and water withdrawal upstream of the Darbandikhan and Hemrin da The research methodology evaluates the hydrological regime using hydrological indicators for various historical period scenarios (1932-2022). The results of trends meteorological analysis and drought indices show an increase in temperature and evapotranspiration, besides the reduction in rainfall rate, especially in the last two decades (2000-2022). In addition, the hydrological analysis shows variation in mean streamflow with a significant decline from the natural flow regime, notably for the summer season for the last two decades.
Moreover, the results of hydrological streamflow indicators show low and moderate hydrological alteration (19-28) % for the period from (1980-1990) and high alteration (37-54) % for the period from (1996-2022). Significantly due to water control and withdrawal by the cascade of multi-purpose dams beside successive drought years. The study illustrated the main challenges and recommended alternatives for conserving the river's ecology besides strengthening the negotiation of water policy, especially in international river basins.
Finally, the study highlights the significant rule of "Rational water resources usage and no harm". In other words, "Sharing the water resources benefits, besides sharing water scarcity harms" due to climate changes and anthropogenic developments impacts for reduce rivers hydrological alteration and environmental protection between the riparian countries.

Characteristics Analysis of Non-Stationary Water Level in Huangpu River

Zhihui Liu[1], Shuguang Liu[1]
[1]Tongji University, Shanghai, China.

As a key parameter for design water level calculation, extreme water level is also an important basis for hydraulic engineering planning and design. Due to the influence of climate change and the human activities, the extreme water level of Huangpu River has changed significantly in recent years, resulting in severe flood control situation in Shanghai, a riverside megacity. Therefore, it is of great necessary to grasp the non-stationary change law of water level series under changing environment and clarify the reasons for the non-stationary change. This paper selects the region from the main stream to the estuary of Huangpu River as the research area, based on the extreme water level series of Mishidu Station, Wujing Station, Huangpu Park Station and Wusong Station from 1964 to 2021. The non-stationary characteristics involving tendency, abrupt change and periodicity of the highest and lowest water level series at each station are researched by using Mann-Kendall (MK) trend test, Pettitt change point test and wavelet analysis respectively, revealing the non-stationary change law and space-time distributions of extreme water level series. The attribution analysis is then carried out for quantitatively revealing the influence of multiple factors such as upstream inflow and human activities on the extreme water level change of the Huangpu River. Our results show that the change of extreme water level at the four stations has shown a non-stationary increasing trend since 1964, and the mutation year of each station along the Huangpu River was around 1988. Two subseries were divided with the change-point as the dividing point for all these actual series in the stations. The tide level at the main stream of Huangpu River has been proven to be susceptible to tidal upwelling, and the upper reaches also showing a dependence on the upstream inflow. Through a case study, the study illustrates that improving the flood control standard plays a very important role in controlling the tidal level variation of the main stream by water conservancy projects. It supports an improved understanding of non-stationary change of extreme water level analysis in megacities, providing a more effective technical support to the hydrological impacts, flood disasters and the design and management of waterway water level in areas similar to large basin, which dose has important theoretical significance and application value.

What Future for the Medjerda, And Its Hydraulic Facilities?

Jean Albergel[1], Yadh Zahar[2]
[1]Ministry of Higher Education and Research France, Montpellier, France.
[2]Ministry of Higher Education and Research Tunisia, Tunis, Tunisia.

After having presented the impacts of a large dam, Sidi Salem on the Medjerda the largest River in Tunisia, in Manahaus and the transformation of its delta and outlet in Moscow, Yadh Zahar and Jean Albergel propose to analyse the future of the river and its two main hydraulic structures: the Sidi Salem Dam and the Medjerda-Cap Bon interbassin canal under the triple constrain: climatic, sedimentary and demo-economic.
Using the WEAP hydrological model, they developed an original method to transpose to the Medjerda river, i) the statistical quantiles of monthly discharges distribution of an equivalent watershed in size and topography but in a drier climate (Central basin of Tunisia), ii) the IPCC RCP 4.5 and 4.8 scenarios, iii) an estimate of the new pressures on the water resource: irrigation, drinking water, industrial and touristic water.
They show an increase in dry years when the reserve stock (400 Mm^3) cannot be maintained from one year to the next: 19 years out of 30. With a silting rate of 0.78% per year, the dam would have an end of life in 2110: sedimentation to the normal reservoir level at current dimensions for the 2050 projection. Despite the increase in recurrence in dry years and due to siltation of the dam reservoir, losses through spillages increase in the 2050 projection and even more in the 2100 projection.
The following assumptions are made about water demand: i) stabilization of irrigation, as small increases in cultivated areas can be compensated for by saving water in the irrigated areas, 2) an increase in the need for drinking water, industrial water and touristic water in line with demographic projections, 3) the volumes turbinated are entirely recovered after electricity production. With these hypotheses WEAP simulations have been implemented on 2020 to 2050 on the performance of the Sidi-Salem dam and the Medjerda–Cap Bon inter-basin transfer canal:
For the Sidi-Salem the simulations give: faster siltation; decrease in water stocks; loss of the dam's regulating function; supply/demand imbalance; increased water deficit; degradation of water quality (salinity). The hydraulic capacity of the canal will reach its limits in the 2040s to 2050s due to the climate but also to the increase in demo-economic demand in the regions served. There are 6 months per year of full flow from 2020 to 2040 and 8 months per year of tight flow at the end of the simulations cycle (between 2040 and 2050).

Climate Change and Water Resources Management in the Murray-Darling Basin

Francis Chiew[1]
[1]Commonwealth Scientific and Industrial Research Organization (CSIRO), Canberra, Australia.

The Murray-Darling Basin covers one million square kilometers of south-eastern Australia. The Murray-Darling River is Australia’s largest, most economically important and politically complex river system. Water resources in the Basin support over two million people, about two-thirds of Australia’s irrigated agriculture, and significant cultural and environmental assets.

The first part of this paper will present the climate and hydrological characteristics of the Basin. The paper will describe (i) the high inter-annual and decadal variability in river flows, (ii) the very severe 1997–2009 Millennium drought, (iii) the significantly lower cool season rainfall over the past 30 years, (iv) attribution of the decline in cool season rainfall to anthropogenic climate change, (v) projections of a drier future, and (vi) the amplification of rainfall reduction in the runoff and river flow characteristics. The paper will discuss developments in climate change science, challenges in linking and interpreting climate projections and hydrological modelling to predict water futures, and the need to adapt hydrological models to incorporate new dominant processes to robustly predict hydrological characteristics in a changing climate.

The second part of this paper will present the significant water reforms and initiatives in the Basin to redress over-allocation of water, which have been accelerated by the Millennium drought and projections of a drier future. These include returning water to the environment through purchase of irrigation water entitlements and infrastructure projects, improving irrigation water use efficiency, enhancing provision of water information, and establishing active water markets. These initiatives are helping buffer the system against droughts and will facilitate adaptation. However, the extreme dry end of future water projections would threaten agriculture production, ecosystems and rural communities and would require transformative adaptation and solutions.

Climate Change Impact on the River Runoff of Nizhnekamskoe watershed

Kseniia Kortunova[1], Yury Motovilov[1], Tatiana Fashchevskaya[1]
[1]Water Problems Institute of Russian Academy of Sciences, Moscow, Russian Federation.

Introduction: The climatic caused changes in the river runoff up to 2100 were estimated using the ECOMAG (ECOlogical Model for Applied Geophysics) regional hydrological model and the Global Climate Models (GCMs) simulations of the Coupled Model Inter-comparison Project Phase-5 (CMIP5) across four greenhouse gas emission scenarios known as Representative Concentration Pathways (RCP) 2.6, 4.5, 6.0 and 8.5.

Study Area: The area of the Nizhnekamskoe Reservoir (NKR) watershed (part of the Volga River Basin) is 186 thousand km2. The territory consists of plain (about 2/3 of the catchment area in the western and central parts) and alpine part (eastern part, the remaining 1/3 of the catchment area). Climatic characteristics vary from 300-400 mm annual precipitation and ~3°C of annual air temperature in the south-west of the region to >600 mm and below 1°C of temperature in the north-eastern and eastern parts of regions. The rivers are mainly recharged by snowmelt water.

Data and Methods: Numerical experiments were performed using data from meteorological and hydrological observations in the watershed for the historical (basic) period of 1979-2005. The ensemble of four GCMs (GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC5) of ISIMIP5 project were reproduces the annual air temperature and precipitation for three separate thirty-year periods of the 21st century (2010-2039, 2040-2069, 2070-2099) compared to the historical period of 1979-2005. Hydrological impact of climate changes is evaluated using the ECOMAG semi-distributed runoff formation model.

Results: The results of the simulations show a possible rise in temperature from 2.8-4.5ºC by mid-century and over 6ºC under the most severe (pessimistic) scenario RCP8.5 at the end of the 21st century with an increase in annual precipitation by almost 14%. The simulations by the ECOMAG using the GCMs ensemble showed possible reduction of annual inflow in the NKV to 4-6% by mid-century under RCP scenarios of average hardness RCP 4.5 and RCP 6.0, and by the end of the 21st century under RCP 8.5 scenario - by 8%. Spatial distribution of runoff changes on the area of watershed is discussed.

Conclusion: A slight decrease in the future inflow into the NKR is estimated for all four RCP scenarios due to an increase in evaporation, despite the tendency to increase temperature and precipitation.
This study was supported by the Russian Science Foundation project no. 22-27-00598, https://rscf.ru/en/project/22-27-00598/.

Impact Of Climate Change and Land-Use Changes in Senegal River

Mame Henriette Astou Sambou[1,3], Stefan Liersch[2], Hagen Koch[2], Jean Albergel[3]
[1]Climate Change and Water Resources, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Universite d'Abomey Calavi, Cotonou, Benin.
[2]Potsdam Institute for Climate Impact Research (PIK), RD2 Hydroclimatic Risks, P.O. Box 60 12 03, D-14412 Potsdam, Germany.
[3]Institut de recherche pour le développement, Montpellier, France.

Freshwater - a fragile resource - is essential for life, development, and the environment. Located between Mali, Senegal, Mauritania and Guinea, the Senegal River is a strategic region for the socio-economic development of these countries. The Senegal River's water management in time and space is possible thanks to the existing hydropower reservoir. The Manantali reservoir aims to meet the growing water and energy need of the member states (Senegal, Mali, Guinea, Mauritania). In the future, hydroelectric production is expected to be profoundly impacted, mainly due to the change in river flow caused by population growth, climate change and Land use land cover change. In the coming decades, climate change and changes in land use and land cover will further increase the constraints on the already scarce water resources in the Sudano-Sahelian zone of West Africa. The objective of the study is, therefore, to assess the impact of climate change and land use/land cover change on water resources and hydropower generation of the Manantaly reservoir in the Senegal River basin at Bafing. In this study, we used an eco-hydrological and water management (SWIM) model, driven by ten downscaled and bias-adjusted Global Climate Models (GCMs) and future land use/land cover maps (2050) based on past trends (1986, 2006 and 2020) to generate daily river discharge and to simulate reservoir management under two climate scenarios (SSP 1.26, SSP3-7.0) in 2050 (P1:2035-2065) and 2080 (P2:2065-2095) period compared to the reference period (P0:2065-2080). The reliability, vulnerability, and resilience performance criteria were used to evaluate the performance of the reservoir in meeting its electricity production target.
The result indicated that P1 compared to P0, an increase in annual flow of 6% is forecast for SSP 1.26, while a modest decline of -1% is forecast for SSP3-7.0. P2 compared to P0, a decrease in annual flow of -6% and -14% is expected, respectively, for SSP 1.26 and SSP3-7.0. In addition, the main result is that LULC has a minor effect on annual throughput than climate change. Regarding energy production, the result shows that around 2050, considering the median of the multi-model ensembles, P1 compared to P0, annual energy production will increase by 3% in SSP 1.26 and slightly decrease by slightly -1% in SSP3-7.0. Regarding P2 compared to P0, a reduction in annual energy production of -7% and -14%, respectively, under SSP 1.26 and SSP3-7.0 will be observed. Hydropower generation will be influenced by climate change. It is, therefore, essential to find an adaptation strategy to deal with the adverse effects of climate change. Thus, hybrid systems that combine hydro, solar and wind energy should be given special attention in the basin.

Effects of Climate Change on the Usumacinta River

Yaridalia Ramirez Abundis, Maritza Liliana Arganis Juárez, Ramon Dominguez Mora
[1]Posgrado UNAM-Facultad De Ingeniería, Ciudad de México, Mexico.
[2]CONACYT, Ciudad de México, México.

Introduction: The Usumacinta River is formed in Guatemala and flows into the Gulf of Mexico; its length is 1,123 km and it is one of the largest and most extensive rivers in the country. Along the Usumacinta River there are populations settled on its banks, since the river provides for their subsistence Historically, these populations have suffered major floods the great vulnerability to which they are exposed can be understood. Climate change and its impacts are already present in this river, according to studies that were carried out at the hydrometric stations that monitor this river.

Objectives: Analyzing whether climate change has contributed to increasing the appearance of meteorological phenomena such as floods with more violence and that these affect highly vulnerable populations, this entails raising awareness about the reduction of greenhouse gases and extreme human consumption.

Methods: The hydrometric station 30019 "Boca del Cerro" was studied, which has a record of 73 years and is located 200 m upstream from the Southeast railway bridge, next to which is the town of Boca del Cerro, belonging to the municipality of Tenosique, Tabasco state.
Homogeneity and trend tests were applied to the series of maximum annual flows of this hydrometric station, which resulted in a change in the series with an increasing trend.
Subsequently, the flood study was carried out from: Obtain the maximum flow of the maximums recorded in the time series. The river was traced in the QGIS program, with the help of Google Hybrid and digital elevation models obtained from the page www.earthexplorer.usgs.gov belonging to the United States government. By having the outline, direction and flow of the river, as well as its slope, the HECRAS ® program was used to carry out the flood study through its RAS MAPPER tool, with the help of the digital elevation model, the maps were obtained. of flood.

Results: It was obtained that of the towns that were studied, 90% of them suffer or will be suffering floods if another flow of this magnitude is recorded. Therefore, flood forecasting through stochastic methods is important.

Conclusion: It is important to urgently make visible what is happening with the change in the precipitation series that is reflected in natural runoff and that causes damage from floods. The importance of reducing greenhouse gases is high since vulnerable populations in the world are suffering the consequences and the most worrying thing is that they are not prepared for it, the loss due to floods is considerable and should not continue to happen; It is urgent to propose new research strategies to forecast these phenomena, which will serve to alert future disasters due to natural phenomena and not act after they occur.

Ribeira River Influence on the Cananéia-Iguape Estuarine-Lagoon Complex Using Modelling

Ana Maria Haytsmann[1], Samuel H. Yang[1], Vitor G. Chiozzhi[1], Joseph Harari[1], Elisabete S. Braga[1]
[1]University Of São Paulo - Oceanographic Institute, São Paulo, Brazil.

Introduction: The Cananéia-Iguape estuarine-lagoon complex (CIELC) is a long coastal ecosystem (>90 km) that has suffered a distinct anthropogenic influence in the northern sector since the opening of the Valo Grande, an artificial channel that makes a direct link of the Ribeira de Iguape River to the internal part of the estuary which altered in a significantly way the northern sector of the system. This channel increases the fluvial influence in water body evidenced by a strong salinity gradient. The silting up of the region has been a recurrent problem, modifying the artisanal fishing, tourism and navigation. The studied area is included in a RAMSAR list and is a member of the Biosphere Reserve, besides it, the northern sector is influenced by the anthropogenic action mainly by the river water input across the Valo Grande changing the hydrodynamic and biogeochemical properties are consequently influenced. The particulate matter discharge from Valo Grande going directly to the Mar Pequeno is estimated at 1,000,000 m^3 $year^{-1}$.

Objectives: This study aims to contribute to the knowledge of circulation pattern in this complex region, collaborating to the prevention of environmental impact using the numerical modelling and biogeochemical indicators in the dissolved and particulate for

Methods: This work aims to understand the recent circulation pattern base on physical and chemical data obtained locally as salinity and nutrients mainly phosphate and silicate present in the water and indicators of the terrestrial discharge by river. The terrestrial contribution associated to the fluvial influence and its erosion compared to the most preserved area of the system was simulated in a numerical modelling with updated nutrients data for better reproduction of the simulation in the estuary. The hydrodynamics (resulting from tides, currents and waves) and suspended sediment transport were simulated using the Delft3D-Flow module and the Delft3D-WAQ module. The Delft3D-Flow model developed by Deltares (Delft, The Netherlands) is a 3D modelling suite to investigate hydrodynamics, sediment transport and morphology, and water quality for fluvial, estuarine and coastal environment.

Results: The results evidenced by the model (Delft3D) showed high concentrations of the biogeochemical components in the northern sector of the system caused mainly by the low tidal influence the uses a high retention of these elements in the region. The southern sector showed low river influence and high marine influence, with expected values of dissolved silicon, phosphate and inorganic suspended matter for a preserved estuarine system.

Conclusion: The model showed a good behavior for the region, with good hydrodynamic and water quality results. It is emphasized the use of a model to monitoring the geomorphological development and the biogeochemical alterations of the estuary to assist in preventive measures with the intention of minimizing the anthropogenic impact in the system.

Sensitivity Analyses of River Morphodynamic Parameters Affected by Climate Change

Fabian Beimowski[1], Regina Patzwahl[1]
[1]Federal Waterways and Engineering and Research Institute, Karlsruhe, Germany.

Introduction: As studies show, long-term trends of future river hydrologic and hydrodynamic parameters differ on a large range depending on scenario-based climate change projections. For some rivers these parameters are already part of climate change impact assessment. However, the sensitivity of morphodynamic processes to the effects of climate change is not adequately described yet. In consequence current approaches of long-term development of hydrodynamic parameters used in the process of adaptation to climate-change often assume a fixed river bed.

Objectives: The focus of the overall project is to investigate climate change induced morphodynamic processes and showcase a strategy taking these aspects into account during climate change impact assessment in the context of adaptation to climate change. The presented sensitivity analyses point out relevant morphodynamic parameters that need to be considered in this process.

Methods: Modelling sediment-transport is subject to high uncertainties. In addition to well-known aspects like the natural variability of input data (e.g., topography, grain size distributions in space and time), the selection of suitable sediment transport approaches as well as model-specific uncertainties (spatial discretization etc.) long-term analyses considering climate-change lead to further uncertainties. Among others attention must be paid to changed sediment input as well as the variable discharge hydrograph. In order to investigate these different aspects in a structured manner, the morphodynamic processes addressed by the one-dimensional-sediment-transport-model used will be matched against the climate change affected aspects of the river system. These initial investigations are qualitative and focus on filtering affected parameters. After these expert-based analyses the highlighted parameters will be investigated within a quantitative sensitivity analysis. Therefore, a one-dimensional-sediment-transport-modeling approach is used. This is reasonable to investigate the impact of climate change on rivers morphology on a larger scale in time and space.

Results: Due to the impact of climate change on the hydrologic cycle, one of the most affected parameters is the altered runoff hydrograph. Since this is also the main driver of bedload transport the investigated effects of varied runoff on future morphology will be presented.

Conclusion: To maintain safety and ease of waterway shipping for a period of decades and longer a pro-active sediment-management that involves the impact of climate change is necessary. Therefore, long-term morphodynamic aspects of riverbed erosion and aggradation must be considered in the process of adaptation to climate change. Results of these fundamental studies can be part of up-coming climate change impact assessments which have to take the long-term evolution of the riverbed into account.

Phosphorus Background in Marine Sediments under La Plata River Influence

Glaucia Bueno Benedetti Berbel[1], Elisabete S. Braga[1]
[1] Oceanographic Institute of University of São Paulo, São Paulo/São Paulo, Brazil.

Introduction: The La Plata River is the second largest river of South America and its drainage basin covers an area of about 3,200,000 km². The freshwater discharge onto the continental shelf is estimated about 23,000 m^3s^{-1}, which about 79% is supplied by the Paraná River and the remaining 21% by the Uruguay River. The La Plata River carries around 160.106 metric tons y^{-1} of suspended sediment to the Atlantic, 68% of which is contributed by the upper Paraná-Paraguay Basin. This investigation is located at Southwestern South Atlantic Continental Shelf (SSACS), between 27°10'S (Brazil) and 39°13'S (Argentina) close to the La Plata River mouth.

Objectives: This study presents the spatial distribution of phosphorus chemical speciation in surface sediments of South America Continental Shelf, between Mar del Plata (Argentina) and Itajaí (Brazil) showing La Plata River discharge influence on phosphorus and organic matter distribution pattern observed in winter 2003.

Methods: The study was performed in two regions: Region I (Mar del Plata – Punta del Leste); Region II (Rio Grande – Itajaí). The sampled sediments were sequentially extracted for phosphorous (P) fractionations to measure the following: exchangeable P (Exch-P); iron oxyhydroxide bound P (P-Fe); authigenic P (Auth-P); detrital P (Detrital-P) and organic P (P_{org}). Total phosphorus (P_{total}) was considered as the 5 P speciation sum.

Results: Total phosphorus (P_{total}) concentrations varied from 23.04 to 42.73 µmol g^{-1}. The P fractions were present in different proportions being that Auth–P (34%) and Detrital–P (32%) were the main sedimentary phosphorus forms in the Region I and P_{org} and Exch–P represented the lowest percentages (5%) of sedimentary phosphorus. On the other hand, in the Region II, the percentages of Auth–P, P-Fe and P org were very similar (26-27%). No spatial difference in percentages was observed for Organic Carbon (mean of 0.53 ± 0.32%), Total Nitrogen (0.07 ± 0.03%) and Total Sulfur (0.05 ± 0.03 %).

Conclusion: The predominance of detrital apatite fraction in the total sedimentary phosphorus demonstrated the importance of riverine discharge in governing the abundance of Detrital-P in the Region I, as well physical weathering. In Region II, the increase of organic matter components evidencing the deposition of organic matter resulting from biological production promoted by the upwelling processes in the Santa Marta Grande Cape on sediments.

This knowledge is important to offering a background to the recent works and for the signalization of the global changes.

Abrasion and Sediment Management: Experimental Study in A Rotating Drum

Philipp Gmeiner[1,2], Marcel Liedermann[1,2], Sebastian Pessenlehner[1], Christoph Hauer[1,2], Roland Kaitna[3], Helmut Habersack[1]
[1]Institute of Hydraulic Engineering and River Research, BOKU, Vienna, Austria.
[2]Christian Doppler Laboratory for Sediment Research and Management, Vienna, Austria.
[3]Institute of Mountain Risk Engineering, BOKU, Vienna, Austria.

In the Danube River east of Vienna as a part of the current sediment management gravel augmentation takes place downstream of the HPP Freudenau and gravel from fairway dredging is recirculated upstream with transport distances up to 20 km. In this context especially as pebbles might be transported several times through the reach the question is how large are the size diminution and mass loss coefficients. An additional question is how fast angular limestones are rounded and lose mass. Those angular grains are available from river restorations projects in the reach, and might be used for gravel augmentation. Attrition and size-selective sorting contribute in unknown proportions to the usually observed downstream decrease of grain size in rivers. Separating those two processes in nature remains difficult, and several studies indicate that diameter alone is not sufficient to quantify the volume resp. mass loss due to attrition. Therefore, a laboratory experiment was conducted using a rotating drum, which has an inner diameter of 2.44 m. Well and poorly sorted mixtures of rounded stones were used, matching the main lithologies in the reach. The tangential drum velocities in the experiment ranged between 0.64 and 1.6 m/s, and mass loss and size diminution coefficients were determined for the whole mixture, the different lithologies of the mixture and single stones. For the angular limestones transported within the mixture of rounded pebbles further digital image analysis was used to follow their shape evolution in 2D, as well as in 3D for some of the stones. The results show that the mass loss coefficients are almost equal for the well and poorly sorted mixtures. Gneiss and limestone abrade 3 to 7 times faster than quartz grains, and show a higher variation of the attrition rates. The attrition rate of quartz grains increased with increasing drum velocity, while for gneiss and limestone the values decreased at the highest velocity. The attrition products (<2 mm) mainly consisted of silt, making up 80-90% of the mass lost. The factor to convert between size and mass coefficients - usually assumed to be three - was variable, and as already noted in other studies, this conversion approach seems to be too simplistic. Concerning the angular limestones, they had higher attrition rates over the first 1 to 2 km, during the initial phase of rounding. After the initial phase the angular limestone had three to four times higher attrition rates, compared to sediments from the Danube River. Extrapolation of the laboratory results to the field is the next step to predict changes in size and mass of the pebbles in the reach where the sediment management is taking place.

Downstream Transport of The Suspended Matter Along the Middle Daugava

Dāvis Gruberts[1], Juris Soms[1]
[1]Daugavpils University, Department of Environmental Science and Chemistry, Daugavpils, Latvia.

Introduction: The Daugava is the 2nd largest river in the Baltic Sea area (total length ~ 1005 km, drainage basin ~ 87’900 km^2, annual runoff ~ 20,5 km^3). About half of its annual runoff is formed by the snowmelt waters that transport a significant amount of the suspended matter to the Gulf of Riga. To study downstream transport of the suspended matter along the Daugava in situ, several real-time drift experiments were conducted on the Middle Daugava's river-floodplain system near Daugavpils City (SE Latvia) during the spring floods in 2014, 2016 and 2019 by applying the Lagrangian sampling method.

Objectives: Main objective of this study was to assess an impact of the stream hydrodynamics and riverbed morphology on downstream changes in particle-size composition and concentration of the suspended matter transported by the Daugava’s flood-flows at the peak of the spring floods.

Methods: During each drift experiment, a manned drifting research platform was used to track selected water masses down the main channel during daytime. The platform’s location, its drift speed, the river channel’s depth and main physical and chemical parameters of the moving water masses were recorded manually each 30-60 min. Simultaneously, samples of the suspended matter were collected near the bottom of the moving water 'parcel' by applying a bathometer 1 l in volume. The samples were analysed for the particle-size composition and dry weight of the suspended matter transported downstream. The laser diffraction granulometric analysis equipment Malvern Master Sizer 2000 was used to determine the percentage content of different particle-size fractions.

Results: At the peak of the spring floods, average concentration of the suspended matter in the Middle Daugava is about 0,018-0,019 g l-1. Significant reduction in concentration of the suspended matter has been recorded downstream from Daugavpils during a well-pronounced spring floods of 2019 while random variation around the mean values was recorded at lower flood discharges in 2016. The suspended matter of the Daugava’s flood waters is dominated by five particle-size fractions (15, 50, 125, 300 and 500 µm). Proportion of the finer particles gradually increases while proportion of the coarser particles significantly decreases during their slow-speed movement across the Middle Daugava's river-floodplain system.

Conclusion: Significant reduction of longitudinal gradient of the Daugava’s main channel downstream from Daugavpils results in compositional changes of the suspended matter transported by its flood-floods. The particle-size composition is affected by both, the average drift speed and the depth of the main channel. As the drift speed and the depth decreases, proportion of some finer particles in the moving flood water masses increases, and vice versa. Downstream changes in concentration of the suspended matter in the Daugava's flood waters are also affected by these two factors.

Long-Term Fine Sediment Deposition in Vienna's Danube Floodplain before Channelization

Severin Hohensinner[1], Sabine Grupe[2], Gerhard Klasz[3], Thomas Payer[2]
[1]University of Natural Resources and Life Sciences Vienna, Vienna, Austria.
[2]Wiener Gewässer Management Gesellschaft mbH, Vienna, Austria.
[3]Consulting Engineer, Vienna, Austria.

Introduction and objectives: Investigations on the deposition processes in current alluvial landscapes are commonly affected by multiple forms of human interventions such as local hydraulic measures and reduced sediment transport caused by upstream reservoirs. The presented study focuses on the sedimentation rates and floodplain accretion over 500 yr. prior to major river engineering measures.

Methods: A comprehensive borehole database and research on long-term fluvial dynamics in Vienna's Danube floodplain enabled us to correlate the thickness of fine sediment layers (silt and fine sand) with the morphological age of individual sites before the great regulation program 1870-1875.

Results: Five years after the onset of the sedimentation process on top of a gravel bar, the median deposition rate amounted to 18.60 cm yr^{-1}. In the following decades the rate significantly decreased and leveled off after 300 yr. with median annual rates between 0.15 and 0.10 cm. Five hundred years after the deposition process had started, the fine sediment layer reached a thickness of 2.64 m, of which half already had been deposited within the first 10 yr.

Conclusions: Stabilization of riverbanks in 1870-1875 significantly boosted the long-term annual sedimentation rates by at least 23-41% (depending on the calculation method), although the volume of the suspended load decreased by 18-45% since around 1880. Assuming equal loads today would hypothetically yield a greater increase of the rates. As opposed to the historical situation featuring intensive lateral erosion, natural levee formation along the protected riverbanks has become a common phenomenon today. The thickness of fine sediment deposition and therefore the long-term "climax level" of the floodplain depends on numerous controlling factors including hydrological regime, sediment volume/size, stream power and riparian vegetation. Human interventions, i.e., bank stabilization, also alter the basic conditions for floodplain accretion, leading to greater sedimentation rates and higher floodplain levels.

Bank Erosion of the Guadalquivir Estuary

Juan Pedro Martín-Vide[1], Francisco Núñez-González[1], Carles Ferrer-Boix[1], M. Garcia- Barroso[2], A. Bejarano[3]
[1]Technical University of Catalonia, Barcelona, Spain.
[2]Consultant company Tecnoambiente, Barcelona, Spain.
[3]Port of Sevilla, Environmental Division, Barcelona, Spain.

Guadalquivir river is one of the biggest rivers of the Iberian Peninsula, flowing through most of the Andalucía region. It has been dammed heavily in the XX century for the purpose of regulation, hydropower and irrigation. The capital city of the region, Sevilla, is the site of a port of historical importance since the 16th century, located on its banks inland, at around 90 km of the Atlantic Ocean. For the advantage of the port, the river was straightened by meander cutoffs and branch simplification, from the original anabranching pattern, between 1797 and 1982. The river is an estuary, actually: its flow is mainly governed by the tide, with some disturbances produced by floods.
Starting around 1956 the banks have experienced large, profound scour problems (they receded dozens of meters, measured in plan view, since then; see fig.1). That happened in mostly straight alignments (fig.1) as well as in a few bends. The kind of scouring is not the one related to river planform dynamics in lowland rivers (such as meandering), but one of channel widening by geotechnical factors of the soils that constitute the banks. Fig.1 is an aerial picture of the problem at two different dates, 1956-57, first aerial survey across the country, and present.
An intense technical and social debate has arisen in the last decades, about what are the causes of this scouring. Whether they are the waves and currents produced by ships, the irrigation, the damming, the cut-offs, etc. The presentation is intended to discuss all these causes.

Sensitivity of the Jamuna-Brahmaputra River Morphology to Multidecadal Hydroclimate Variability

Andrew Nelson[1], Maminul Haque Sarker[3], Ashley Dudill[2], Md. Ruhul Amin[4]
[1]Northwest Hydraulic Consultants, Bellingham, United States.
[2]Northwest Hydraulic Consultants, Vancouver, Canada.
[3]CEGIS, Dhaka, Bangladesh.
[4]PMO-FRERMIP, BWDB, Dhaka, Bangladesh.

Between the earliest available remote sensing imagery characterizing the Jamuna-Brahmaputra River, captured in the late 1960s, and the present, the channel belt width has widened by approximately 2 km, resulting in catastrophic loss of land and livelihood for hundreds of thousands of people. This change has been dominantly attributed to the effects of a sediment pulse generated by the 1950 Great Assam Earthquake. However, new data explored in this paper showing multidecadal variability in the river's discharge, also provide an explanation of the historically observed river behavior.

Traditional regime theory suggests that channel adjustment would be expected in response to variability in the "channel forming discharge" but offers little guidance in selecting the timescale for definition of that discharge in cases of either cyclical or secular variation in flood flows. We integrate established hydraulic geometry relations with newly available long-term proxy records of Jamuna-Brahmaputra River discharge and records of channel width to explore relations between decadal-timescale hydroclimatic variability, channel width, and channel belt width to explore how the channel adjusts to variability in flood flows. We find that the magnitude of very recent (trailing 1 to 4 years) flood peaks largely explains much of the observed variability in the active channel width. Further, the narrow condition observed in the 1960-70s represents a response to one of the lowest flood periods in seven centuries, and channel widening in the 1980s and 1990s followed patterns of a regime response to increased channel forming discharge. These results suggest that the channel geometry of rivers with sediment transport-limited conditions and highly mobile sediment, such as the Jamuna-Brahmaputra River, may be in a continuous dynamic equilibrium state of adjustment to variable flood flows.

These findings have major implications relevant to planning efforts to reduce flood and erosion vulnerability along the river. The narrow 1960s-70s channel should not be considered a normal condition for the river, and future increases in frequency and magnitude of flood flows expected in response to climate change should be anticipated to result in further channel expansion. River management activities may mitigate some of the expected widening, but the channel size will still adjust to increased discharge by deepening. This deepening will likely impact scour depths against bank protection features. The combined effect of increased settlement density near the river, increased flood water levels behind levees, and increased probability of scour-induced failures of bank protection features protecting such levees may result in a substantial increase in hazard if an adequate corridor width to account for future climate change is not preserved.

Numerical-Modelling and Earth-Observations for Dynamic Management of Old Brahmaputra Offtake

Amgad Omer[1], Asheque Mahmud[3], Mohamed Yossef[1], Farhana Akhter Kamal[3], Jakia Akter[4], Erik Mosselman[1,2]
[1]Deltares, Delft, Netherlands.
[2]Delft University of Technology, Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft, Netherlands.
[3]Institute of Water Modelling (IWM), Dhaka, Bangladesh.
[4]Center for Environmental and Geographic Information Services (CEGIS), Dhaka, Bangladesh.

The Old Brahmaputra River (OBR) provides water to the mega city Dhaka and for navigation. Due to large morphological changes in the Jamuna River, the shape and elevation of the OBR offtake were deposited. The braided Jamuna River's morphological changes have caused the offtake area of the OBR to be unstable to provide less water than demand. The Old Brahmaputra River is the lifeline of the Jamalpur-Mymensingh region of Bangladesh and serves various ecosystem services such as a source of drinking and domestic water, irrigation, fisheries, navigation and so on. The study aims to assess the morphological characteristics of the OBR offtake and to develop suitable offtake management options through structural and non-structural interventions. Furthermore, innovative dredging options will be explored in the river reach to ensure sufficient flow in the dry season at the OBR and its distributaries along with other water usage. Ecosystem services in the river are also tackled. In this context, the offtake management options are simulated with mathematical models to find a sustainable option to stabilize the offtake and ensure dry-season flow in the river for sustaining ecosystem services.
A new approach has been developed to retrodict a former bed topography with the support of satellite images. The quasi-3D numerical model is hydrodynamically calibrated at two locations (Bahadurabad and Chilmari). In addition to that, the model is calibrated in terms of sediment transport capacity for morphology. The Engelund-Hansen sediment transport formula has been modified to best fit the measured sediment transport data. Furthermore, many simulations have been conducted to capture deposition and erosion of the flooding and drying locations within the river. Simulation results at these locations are used as key performance indicators (KPIs), obtaining information for them via earth observation data. After this process, the best model setting is selected to declare that the model is fit for purpose.
The quasi-3D fit-for-purpose model is used to perform several scenarios to assess the effect of various measures and interventions on the offtake functioning. These measures are selected upon stakeholder sessions that are conducted for the purpose to collect all the possible options. Selected measures and a combination of measures are implemented in the model and tested (e.g. moderate dredging, aggressive dredging, use of geo-tubes, bank fixation and guide walls, and development of a second offtake).
The results illustrate that the measures do increase the volume of inflow discharges of the OB River. However, the optimal strategy must be selected based on the intervention strategies' demand and tractability. This has to be further investigated to ensure the selected strategy has minimum impact on people, the planet and prosperity.

Sediment Transport of Narva River

Marina Shmakova[1]
[1]Institute of Limnology RAS, Saint-Petersburg, Russian Federation.

In the practice of economic use of water bodies, calculations of solid runoff of various scales are relevant – from second to annual. The estimation of annual solid runoff as well as the estimation of statistical parameters of turbidity and the degree of its reliability is extremely difficult in case of irregularity and insufficient illumination for different phases of the water regime. At the same time, the study of the processes of formation of natural water quality and the creation of a sufficient sets of calculation methods allow us to reproduce the main indicators of water quality with acceptable accuracy. A comprehensive approach to evaluating water quality indicators through well-established deterministic and stochastic calculation algorithms with arguments that are observed regularly and for a long time allows us to expand the possibilities of statistical analysis of water quality indicators.
The Narva River is a transboundary watercourse of great water management importance. The sediment runoff at the Narva River gauging station - the village of Skamja is regulated by Lake Peipsi, which acts as a settling tank for suspended mineral particles coming from the catchment area and from the runoff of tributaries. Downstream, the low turbidity of the Narva River is determined by the influence of the Narva reservoir, which also acts as a sediment settler.
In order to estimate the parameters of sediment discharge or turbidity distribution, a deterministic-stochastic modeling system "weather - runoff - soil erosion - sediments", based on stochastic weather model, models of liquid and solid runoff formation in the watershed and a model of annual solid runoff, is used. The system makes it possible to estimate parameters of the distribution of daily values of sediment runoff and turbidity in case of insufficient observational data and under conditions of changes in runoff formation in the watershed, which occurred as a result of natural causes or economic activities.
Analysis of the intra-annual distribution of water turbidity showed asymmetric distribution towards higher values. The lowest values of turbidity occur during winter and spring low-water periods, the highest values - during floods and autumn-winter floods. According to calculations of soil erosion intensity, it follows that, on average, during the ice-free period, the products of soil erosion account for 82% of the total sediment load. The numerical implementation of the climate forecast has shown that a decrease in river flow caused by an increase in air temperature will lead to a significant increase in water turbidity.

Evolving Columbia River Basin sediment loads, late 1800s-2020

David Jay[1], Margaret McKeon[2], Heida Diefenderfer[1], Stefan Talke[3]
[1]Portland State University, Portland, United States.
[2]Pacific Northwest National Laboratory, Sequim, United States.
[3]California Polytechnic San Luis Obispo, San Luis Obispo, USA.

The Columbia River is unusual in that it is the largest river to run through the coastal mountains on a subduction zone coast, and does so despite a rapid rate of tectonic rise. Its profile is steep and glaciation is prominent, but it has a relatively low sediment load, probably because much of the basin is made up of recent volcanics, scoured by post-ice age floods. The seaward 234 km of the system are tidal, though salinity intrusion is typically only 20km. Large-scale human manipulation of the basin has occurred primarily since 1850, but it hosts one of the world's most intensively developed hydropower syste Some 50 years have passed since the last large-scale assessment of Columbia River Basin (CRB) sediment supply and fluxes, and the tributaries have never been evaluated systematically. Since that time, the flow regime has been altered by the CRB hydropower system, irrigation withdrawal and climate change. Coarse fractions are increasingly trapped behind the ~300 dams in the system, and water quality regulations have curtailed fine sediment inputs. To understand and quantify changes over time and see how they vary along the channel, we assemble available sediment concentration and fluxes for the system ca. 1900 to date. At least some data are available from streams draining 80% of the basin. We find that coarse load supplied to the estuary has been decreased about 75%, while fine load is down 67%. The loss of sediment supply is cumulative, increasing in the seaward direction, and the greatest changes have occurred since about 1980. High in the basin, the hydropower system is responsible for most of the loss, through reservoir trapping. Closer to the ocean, loss of inflow and alteration of seasonality by flow regulation, climate change and irrigation become more important. Tributary load decreases are smaller than those in the mainstem, emphasizing the importance of lower and middle-basin tributaries to the estuarine sediment budget. Also, volcanic eruptions in coastal tributary basins have, over the past several thousand years, supplied a large fraction of the load, a situation that has been altered by modern management. Thus, most of the 100 million cubic meters of sediment from the 1980 Mt St Helens never reached the mainstem, because large rises in the bed would have caused serious urban flooding and also possibly clogged the cooling pumps of a nuclear reactor. The combination of reduced sediments load to the estuary and sea level rise threatens the stability of both wetlands and the navigational jetties at the river mouth. Sediment to the estuary is in approximate equilibrium with dredging and other losses, assuming zero export to the ocean. Export is unknown, but thought to be small at present, threatening coastal stability.

Sediment Balance and Transport in The Five-Country Biosphere Reserve Mura-Drava-Danube

Roman Dunst[1], Mario Klösch[1], Ulrich Schwarz[2], Kerstin Böck[3], Helmut Habersack[1]
[1]BOKU University of Natural Resources and Life Sciences, Institute of Hydraulic Engineering and River Research, Vienna, Austria.
[2]FLUVIUS Floodplain Ecology and River Basin Management, Vienna, Austria.
[3]WWF Austria, Vienna, Austria.

The Mura, Drava and Danube form a 700 km long corridor through Austria, Slovenia, Hungary, Croatia and Serbia, connecting 10 000 square kilometers of natural and cultural landscapes. To protect these ecologically highly valuable areas, the Ministers responsible for environment and nature conservation of Austria, Croatia, Hungary, Serbia and Slovenia signed a joint declaration in 2011 to establish the reserve, with the designation finally achieved in September 2021.
As many rivers, the Mura, Drava and Danube experienced anthropogenic alteration along their course. Despite longer free-flowing sections, artificial structures in the upper regions and sediment mining (conducted until 2011) heavily affect the sediment balance in the study area and significantly altered the morphology of the rivers. Within the lifelineMDD project, the sediment conditions in the TBR MDD area were assessed, serving – together with studies on sediment mobilization, training structures and historical mapping, the fish and bird status, climate change and hydropeaking – as scientific base for the River Restoration Strategy, a joint commitment for future restoration works in the TBR MDD.
Due to the hydropower plants established upstream of the Biosphere Reserve a century ago, effectively no actual bedload enters the Biosphere Reserve by Mura and Drava from upstream. The lack of sediment input in combination with increased transport capacity due to morphological changes (e.g., decreased sinuosity; narrowing proved by the historical analysis) results in bedload transport from bed degradation and – if possible – bank erosion in the free-flowing sections. This is not sustainable on the long run and led to the TBR rivers incising into their alluvium; e.g. along a 30 km stretch of the Border-Mura between Austria and Slovenia, ca. 29,000 m³ of gravel is eroded annually from the riverbed, rapidly decreasing the already thin gravel layer in this section.
Analyses of the river stages at low flow show river bed incision reaching e.g. up to ca. 2.7 m since 1925 at Terezino Polje. This trend is still ongoing, as the assessment of water surface elevations at mean discharges show (e.g., 2.5 cm per year at Terezino Polje since 1990). Recent developments since 2010 along the Danube show mean annual incision rates between Baja and Ilok between 1.5 cm per year (Mohács) and 3.7 cm per year (Baja).
When implementing measures to counteract this trend in the TBR, e.g., widenings and increasing sinuosity, providing sediment input along with sufficient lateral space is key for the river to develop a dynamic sediment balance and consequently a sustainable natural river morphology. Implementing large measures ensures a high efficiency due to more bedload provided in the construction phase and less supply needed due to the decreased transport capacity.

GIS Assessment of Sediment Pathways Within Lena River Catchment

Sergey Chalov[1,3], Oleg Yermolaev[2], Y Shynbergenov[2], Kirill Maltsev[2]
[1]Lomonosov Moscow State University, Moscow, Russian Federation.
[2]Kazan Federal University, Kazan, Russian Federation.
[3]Kazimir Velikiy Bydgoszcz University, Bydgoszcz, Poland.

The study presents novel GIS database for one of the largest World rivers Lena River which catchment covers significant part of Siberia and is located mostly in permafrost zone. The automatic GIS procedure was used to delineate catchments of 2-3 orders and prepare vector map (1:1000000). 52383 catchments with an average area of 47 Km^2 were created. Additionally, the database included over 40 environmental and human impact drivers. Based on this database, the calculations of rainfall soil erosion (04 t/ha/year) were done by RUSLE erosion model with the spatial resolution 250 m GMTED DEM 2010. To calculate hillslope and rill snowmelt erosion. the model by Larionov-Krasnov was used (Larionov and Krasnov 1997). A detailed historical analysis of riverbeds, considering available satellite images to assess the Lena rivers planform changes, was performed. Bank erosion was measured as bank retreat along studied rivers based on the GSWE automatic image interpretation data. The bank erosion contribution was estimated for the Lena River the reach from Kusur to Malykan (1800 km from the mouth) was considered.
The results indicated the average catchment erosion as 0.04 t/ha/year (0.01 t/ha/year for melting erosion and 0.03 t/ha/year for rainfall erosion). The regions with high erosion intensity (> 100 t/ha/year) covers around 0.0003 % from the total area. The spatial distribution of the catchment erosion contribution is prone to longitudinal variations and also indicate higher susceptibility for erosion over Eastern parts of the catchment due to piedmont topography. In the lowland Western areas, the low values of erosion are dominant (less than 0,5 t/ha/year). For the Lena total watershed erosion is 880 Mt ye-1 (or 845 Mt ye-1 without reservoirs catchments), the bank erosion estimated as 338 Mt/year (1800 km of downstream from the delta to Syniyakhatah village). Accounting only the catchment area downstream from the major reservoirs, 1183 Mt/year of sediments are currently stored in the watershed and river valley of the catchment respectively. Due the fact that the largest reservoir is located on the Vilui River which is drained relatively stable territory, the available for the sediment export volume of catchment erosion products is reduced up to 4% of the gross soil wash. We assume, that under present hydro-climatic conditions about 96-97 % is stored in various buffer zones of the catchment and river network.

Toxic Prymnesium Parvum Blooms During Fish Kills in Oder River

Agnieszka Napiórkowska-Krzebietke[1], Hanna Mazur-Marzec[2], Elisabeth Varga[3], Krystyna Kalinowska[4], Konrad Stawecki[1]
[1]National Inland Fisheries Research Institute, Department of Ichthyology, Hydrobiology and Aquatic Ecology, Olsztyn, Poland.
[2]University of Gdańsk, Institute of Oceanography, Division of Marine Biotechnology, Gdańsk, Poland.
[3]University of Vienna, Department of Food Chemistry and Toxicology, Vienna, Austria.
[4]National Inland Fisheries Research Institute, Department of Lake Fisheries, Giżycko, Poland.

One of the largest rivers in Poland, Oder River rises in the Czech Republic and flows by 742 kilometers through western Poland. In August 2022, this river was affected by an ecological catastrophe with massive fish kills never noted before. Some literature data indicated that toxic golden alga Prymnesium parvum was responsible for fish kills in at least 14 countries including every continent. In general, fish kills occurred at cell counts above 50-100 million cells/L. The aims of the study were to (1) identify the occurrence of P. parvum, (2) assess its density and toxicity, and (3) indicate the key factors responsible for its bloom forming.
The first water samples for phytoplankton analyses including especially golden alga were taken in August, 2022 at sites where massive fish kills occurred in Oder River. Then, the water sampling was continued until November 2022. The water samples were taken from subsurface layers of Oder River, and additionally from water bodies connected with the river. The water samples were analyzed for P. parvum density and toxins relative concentrations, and for physicochemical parameters. All analyses were carried out according to standard methods.
The first identification of Prymnesium parvum was made in the samples taken during the massive fish kills. In the period of August-November 2022, the density of P. parvum ranged maximally to 600 mln cells/L. This alga was checked for the possibility to produce the toxins, and it was found three different prymnesins of the B group. The sum of prymnesins amounted maximally to 83 nmol/L. High alga density and prymnesins content corelated with the fish kills events recorded in Oder River in August and September 2022.
P. parvum was found in 369 from 420 samples analysed, i.e., in ca. 88% of all samples. The densities above 50-100 million cells/L were found in 40% of samples, especially with high values of electrolytical conductivity, pH, water temperature, and low nitrogen and phosphorus content. Such densities corelate with the threshold values related to the fish kills, commonly observed all over the world. There was statistically significant relationship between relative concentration of prymnesins and Prymnesium parvum density. Based on the value of the correlation coefficient (r = 0.597 in August-September), this relationship was described as moderately high.
Summarizing, in Oder River golden alga Prymnesium parvum was very commonly found in phytoplankton assemblages. This alga was found in majority of water samples analyzed, and in ca. half of them density values were at high level commonly found during the massive fish kills all over the world. P. parvum produced prymnesins of the B group, related especially to alga density, water salinity, water temperature, nutrients, pH, and massive fish kills, especially in the middle course of the Oder River.

Modeling Refuge Habitats for Rejuvenation of The Odra River

Piotr Parasiewicz[1], Shubham Wagh, Katarzyna Suska, Andrzej Kapusta
[1]National Inland Fisheries Research Institute, Olsztyn, Poland.

In August 2022 a major fish kill occurred on the Odra River in Poland affecting over 700 km of the river. length. Although a bloom of the primnesium parvum algae releasing potent toxin was the key culprit, the high-water salinity, together with hydrological and hydromorphological conditions created the perfect circumstances for the catastrophe.
In order to investigate the mechanisms and develop science base for future preventive actions a multiplex habitat model was developed for the fish community of Odra River. The model input data is a combination of hydraulic measurements, orthophotomaps, multispectral and thermal imagery. The first objective was to describe a distribution of fish and mussels refugia. The model uses hydrodynamic River2D, micro- and mesohaitat models to identify hydraulic habitat for fish and mussel species. The multispectral imagery of affected River’s area has been captured from the airplane shortly after the fish die-offs. It is used to determine the spatial distribution of toxic pollutants. The thermal imagery offers surface water temperature maps. This information was superimposed over the hydraulic model to create refugia habitat model used to identify high and low risk habitats at low flow conditions occurring during the die-off and beyond. Habitat simulation is applied as a tool for determination of habitat improvement measures increasing resilience and resistance of the ecosystem.

Euphrates River Water Quality by Remote Sensing and GIS

Jasim Ali[1]
[1]Iraqi Ministry of Water Resources, Anbar Water Resources Directorate, Ramadi, Iraq.

This paper investigates the Euphrates River water quality in Anbar Province, which is located in the west of Iraq, using Remote Sensing (RS) and Geographical Information System (GIS) techniques. The method used two Landsat 7 ETM+ images from 2002 and 2010 and water quality parameters from a field study that was carried out on the river between Heet and Ramadi Cities. The relationships between at-ground reflectance and recorded water quality parameters were built using multiple linear regression backward elimination. The water quality parameters that showed significant correlations with at-ground reflectance were Mg, Ca, Na, K and turbidity.
Thermal pollution was also investigated and results showed increases in reflectance and temperature values from Ramadi to Falluja. Even though the predicted temperature values were within the Iraqi drinking water standards, the overall temperatures rose by about 1ºC and this is likely to have a negative impact on the ecology of the area. Overall trends illustrated that the river pollution increased as the river moved from Ramadi to Falluja. Moreover, the temporal change of water quality between 2002 and 2010 differed spatially, so the river’s water quality near Ramadi in 2002 was better than in 2010. Nevertheless, as the river moves towards Falluja the water quality improved between 2002 and 2010.

Anthropogenic Debris Monitoring using a Littertrap at the Rhine River

Katharina Hoereth[1], Nina Gnann[2], Leandra Hamann[1], Niklas Prophet, Nicolas Schweigert
[1]University of Bonn, Bonn, Germany.
[2]University of Koblenz, Koblenz, Germany.

Plastics are one of rivers' main pollutants that can linger within river systems for years, influencing water quality and endangering ecosystems and biodiversity. In-situ data is thus necessary to quantify the extend of pollution, to sensitize citizens and to derive regulations and strategies in politics and industry to reduce plastic pollutants. Particularly in large river systems, debris monitoring is challenging due to environmental conditions, e.g., large river widths and depths, varying water levels, debris occurrences and the differences within monitoring techniques.
A quantitative monitoring concept to detect anthropogenic debris is currently tested using a litter trap in the River Rhine, the river with the highest discharge in Germany flowing into the North Sea. The litter trap consists of a permanently anchored platform of 4.7 m width and 11.6 m length, positioned at kilometer 691 in Cologne, Germany. The basket inside the floating litter trap is 2.94 m wide and collects floating debris up to a water depth of 1 m. The collected debris is evaluated at biweekly intervals by a transdisciplinary team of researchers supported by volunteering citizens of the K.R.A.K.E. association. The collected debris is analysed with an adapted version of the Joint List of Litter Categories for Marine Macrolitter Monitoring by the Joint Research Centre (macrolitter list) that includes over 8 material type categories and 104 litter categories.
This project aims to identify material type, type of use, litter category, the number, weight and size of the collected litter items and links this data with environmental parameters, such as water level or rain fall, and social events, such as Carnival or New Year’s Eve celebration. Preliminary data from September to December 2022 depicts macroplastic as the largest part of the non-organic alluvial load collected in the litter trap with 74%, followed by glass and ceramics with 9%. Specific categories of macro plastics like fragments (24%), bottles (18%) and wrappers (6%) have occurred most frequently. The data collected so far indicates that periods of rising water levels lead to a high amount of flotsam in the litter trap.
The harmonised monitoring approach based on the macrolitter list ensures the comparability with data collected at various sites and with different monitoring lists, e.g., OSPAR-IDs. Temporal data about the debris load in the Rhine River is collected and can be used to estimate the total annual load across the river. This information can support the implementation of purposeful measures and policies to further reduce debris sources that have been identified through the monitoring. Working together with the association K.R.A.K.E. connects science and citizens and enables education and awareness for the future sustainable handling of plastic pollution in rivers.

Monitoring Coastal Riverine Litter Accumulations in the Tisza River Basin

David Attila Molnar[1], András Kristóf Málnás[1], Miklós Gyalai Korpos[1], Máté Cserép[2]
[1]Plastic Cup Initiative, River Monitoring Unit, Budaors / Wudersch, Hungary.
[2]ELTE Eötvös University, Faculty of Informatics, Budapest, Hungary.

The Tisza River the longest (966 kms) tributary of the Danube, its water catchment area exceeds 150,000 km² in 5 countries (Romania, Ukraine, Slovakia, Hungary and Serbia). Long term observations in the Tisza River Basin (TRB) revealed that during floods the heavily polluted river can carry as much as 500 plastic bottles per minute; a sadly spectacular event named the plastic flood. Most of the riverine litter accumulations are formed in the floodplains filtered by the littoral vegetation (alluvial forests cover more than 33.000 hectares in Hungary alone). After dense undergrowth made attempts for aerial survey unsuccessful, the Hungarian river cleanup initiative Plastic Cup launched a multiyear citizen science program to carry out personal observations along the entire Tisza River and some of its tributaries. In the framework of 3 international river cleanup projects (Tid (y)Up, 5 countries 1 river, Clean Water Happy Tisza) volunteers registered and reported coastal riverine litter accumulations based on the protocol of the Transnational River Cleanup Handguide. The personal survey of the extensive floodplains lasted 6 consecutive years (2016-22) in 5 countries. Observations were carried out mostly in winter when scarce vegetation made the detection of coastal riverine litter accumulations possible. Geolocation, ID, textual description and pictures of the polluted sites were registered and reported by a free and open-source smartphone application. In lack of mobile signal reception, the device cached the data and transferred again once it was back online. After the report, using the JSON format and the API endpoint provided by the application, data was transferred to the servers of the online pollution map. To cover the whole TRB, monitoring activities included River Tisza (entire river, both shorelines) and sections of smaller tributaries. Data visualization was carried out via an automated process making sure that a newly discovered pollution site appears on the online map within 15 minutes of its detection. In the TRB, since January, 2016 volunteers have reported 3216 coastal riverine litter accumulations. With 2667 reports the Tisza was covered in its entirety from the source to the Danube. In conclusion, the floodplains of the lower section of the Tisza function as a repository for large amounts of floating riverine litter not only because of natural reasons but due to artificial water engineering facilities such as hydroelectric power plants (HEPPs). Our data suggest that the retention capacity of alluvial forests, combined with the low-flow sections of the river formed by natural and artificial causes leads to the formation of large riverine litter accumulations. These results suggest that rivers not only serve as a transport route for marine litter: by filtering out the pollution they become more and more polluted themselves, if proper preventive and reactive actions are not taken.

Chemical Monitoring at the River Rhine – Tomorrow Is Yesterday?

Lars Duester[1], Daniel Heintz[2]
[1]Federal Institute of Hydrology, Koblenz, Germany.
[2]International Commission for the Protection of the Rhine, Koblenz, Germany.

The river Rhine connects six nations – from Switzerland to the Netherlands. The catchment area is about 185,000 km² and includes nine countries. With a total length of 1230 km and a mean water runoff of >6000 m³/s on the Dutch-German border it is one of the largest rivers in Europe. In addition, the catchment includes some of the most densely populated and industrially developed areas and it is the most important waterway in Germany. The International Commission for the Protection of the Rhine (ICPR) was founded in 1950 in order to protect the Rhine from pollution, to increase biodiversity and to reconciliate the ecology of the Rhine with its other functions.
The chemical base parameters have been monitored and documented along the river since the beginning of the 20th century. International cooperation has a long and lasting tradition at the Rhine. The Sandoz chemical accident that leads to a fish kill in 1986 additionally fostered the international exchange and cooperation. For several reasons, scientific and regulation-based monitoring efforts undergo a paradigm shift at the moment. The most significant impact might be the growing public awareness, that potential drinking water resource river water is becoming scarce, under changing environmental conditions in many countries. With respect to the chemical status of major rivers, even though most of the rivers in central Europe became “cleaner” as regards the macro constituents, an increase in demands is visible, not only for the presence of micropollutants. For the neighboring countries, the low water event 2018 was worrying and alerting. It created, not at least, significant adverse economic effects.
The presentation delivers an overview on the internationally coordinated chemical monitoring efforts (incl. radioisotopes) along the Rhine. It includes experience from the past, describes the recent status and throws a glance into the future and at trends, owning the potential to create an impact in the medium term (e.g., 24/7 multielement or non-target analyses in monitoring approaches).
The presenting author is the head of the division G4 (Radiology and Water Quality Monitoring) of the Federal Institute of Hydrology, responsible for monitoring activities at all major German rivers (e.g., Elbe, Oder, Ems, Weser, Mosel, Main, Neckar and Danube) and he is head of the expert group monitoring (SMON) of the ICPR (https://www.iksr.org/en/icpr/about-us/organisation/working-group-water-qualityemissions/eg-smon/).
Marc Daniel Heintz is Executive Secretary of the ICPR’s secretariate in Koblenz, Germany (https://www.iksr.org/en/icpr/about-us/secretariat).

Heavy Metal Contamination in Floodplain Area Along the Mekong River, Laos

Thipphachanh Souliyavong[1], Kim Kyoung-Woong[1]
[1]Gwangju Institute of Science and Technology, Gwangju, South Korea.

Introduction: Over a decade, Laos has encountered many kinds of natural disasters, especially flooding events caused by heavy rainfall related to climate change. During these flooding events, some parts of the Mekong River and its tributary flowing through industrial areas may transport large amounts of pollutants into the lower catchment area. However, the study on the influence of water quality and heavy metal contamination caused by the effect of climate change in Laos is still unknown.

Objectives: The present study aims to determine the effect of climate change on water quality and heavy metal contamination in the food chain of rice and drinking water in floodplain areas along the Mekong River and its tributary in Laos.

Methods: Various types of samples were collected during the rainy season. we investigated the physical-chemical properties including pH, EC, DO, TSD, and Cation-Anion of the Mekong River and groundwater in floodplain areas according to APHA procedures. Heavy metal concentration (Mn, Fe, As, Cu, Cd, Pb, Hg, and Ba) was determined by using Inductively coupled plasma mass spectrometry (ICP- MS) for both water and crop plant samples. The USEPA method was applied to investigate health risk assessment.

Results: The physical-chemical properties of the Mekong River and its tributary are in the normal range under the permission limit, except for NO3- which is shown in high concentration. The major cation and anion followed the orders of Ca2+ > Na+ > Mg2+ > K+ and SO42- > Cl- > NO3- > PO43-> Br- > F- > NO2- respectively. Heavy metal concentrations in river water were lower than the WHO permission limit. However, the maximum value of As and Pb were detected in groundwater samples of 36.7 ug L-1 and 11 ug L-1, and in the rice grain samples of 0.6 mg kg-1 and 0.22 mg kg-1 respectively. Health risk using hazard quotient (HQ) and hazard index (HI) for non-carcinogen risk and Incremental Lifetime Cancer Risks (ILCR) for carcinogenic risk by oral ingestion of groundwater and rice grain are assessed, it shows that as may be related to a potential non-carcinogenic risk (HQ and HI > 1), while As and Pb may potentially cause the carcinogenic risk (ILCR > 10-4) by oral ingestion pathway of groundwater.

Conclusions: The water quality of the Mekong River and its tributary, and the heavy metal concentration in the food chain of the floodplain area were studied, and the result has shown that the water quality of the Mekong River was in the normal range. However, high heavy metal concentrations were found to exceed the permission limit in both groundwater and rice grain samples. It may be related to potential non-carcinogenic risk and carcinogenic risk by ingestion pathway.

Modelling the Concentration of Antibiotics in The Global River System

Bernhard Lehner[1], Heloisa Ehalt Macedo[1], Jim Nicell[1], Usman Khan[1], Eili Klein[2], Günther Grill[1]
[1]McGill University, Montreal, Canada.
[2]John Hopkins University, Baltimore, United States.

The presence of antibiotics in surface waters can pose important risks to aquatic ecosystems and human health due to their toxicity or influence on antimicrobial resistance. Here a high-resolution global contaminant fate model called HydroFATE was used to estimate concentrations of 40 antibiotics representing those that are most frequently used in households worldwide and which, after consumption and metabolism, are emitted to surface waters via domestic wastewaters. This comprehensive approach involved the simulation of the emission and fate of multiple antibiotics in the global river system, accounting for and integrating their spatially explicit pathways, removal processes along their pathways, and producing estimates of the resulting cumulative concentrations of the substances in surface waters. These antibiotic concentrations were then compared to established no-effect thresholds of environmental exposure and converted to defined daily doses to estimate human exposure. It was found that 6.0 million km of rivers worldwide show environmental exposure levels that exceed the no-effect concentration of antibiotic pollution during low streamflow conditions, with the largest extent of these rivers being in Southeast Asia. Out of a comprehensive dataset of the 40 most-used antibiotics, those that were identified as the potential main contributors of exposure were found to be amoxicillin, ceftriaxone, and cefixime. In terms of human health exposure, it was estimated that 2.4 billion people live within 10 km of rivers that have antibiotic concentrations exceeding 3 microdoses per liter, representing the 95th percentile of concentrations in all investigated rivers, which may lead to a concern of chronic exposure if these surface waters are used for direct human consumption. Of these exposed people, 52% are residents of China or India. The utility of HydroFATE primarily lies in its use to guide the development of targeted local monitoring schemes in regions of highest exposure and to inform appropriate management plans, regulations, guidelines, and wastewater treatment practices, all with the common goal of safeguarding the health of ecosystems and human populations who depend on water quality.

Spatial Distribution of Anthropogenic Radionuclides in the Soil-Freshwater Ecosystem

Lydia Bondareva[1]
[1]Federal Scientifiec Center Named After F.F. Erisman, Mytischi, Russian Federation.

The Arctic, included Siberian territory, contains an abundant and wide range of freshwater ecosystems, including lakes, ponds, rivers and streams and a complex array of wetlands and deltas. This broad range of freshwater ecosystem types contains a multitude of habitats of varying ecological complexity and supports a diversity of permanent and transitory organisms adapted to living in an often highly variable and extreme environment. Moreover, these habitats and species provide important ecological and economic services to northern peoples through the provision of subsistence foods (fish, aquatic birds and mammals), serve as seasonally important transportation corridors (e.g. ice roads), and are ecologically and culturally important habitat for resident and migratory aquatic species. Global environmental changes not only contribute to the modification of global pollution transport pathways but can also alter contaminant fate within the Arctic. Recent reports underline the importance of secondary sources of pollution, e.g., melting glaciers, thawing permafrost or increased riverine run-off. In addition, consideration is migration anthropogenic radionuclides in system soil-freshwater ecosystem and also given to the possible consequences of accidents and other possible future sources of contamination in the Arctic. The major contaminant groups in the Arctic are persistent organic pollutants (POPs), heavy metals and artificial radionuclides.
Samples of soil, grass and organs of herbivore mammal were collected from different sampling locations in five states within the south-western area of the Arctic of central Siberia. The activity concentrations of natural and artificial radionuclides present in the collected samples were detected with a method of gamma spectrometry using High Purity Germanium detector.
Much of the nuclear activity of the Russian Federation took place within or adjacent to the confines of the Ob and Yenisei Rivers drainage basin. These sites have been the locations of accidental and planned releases of major amounts of radioactive materials since the dawn of the nuclear era. More important, these sites contain vast amounts radioactive waste, in storage, released to the environment, and injected into geologic formations at relatively shallow depth. Since the Yenisei and Ob are of the largest rivers flowing into the Arctic, there has been considerable concern over past delivery of radioactive contaminants to the Arctic and the potential for much larger future releases.
Also, our research reveals the gradual emergence of a new source of radioactive contamination in high latitudes of the Arctic that is essentially secondary by origin. Anthropogenic radionuclides (137Cs, 241Am, and 207Bi) produced in atmospheric nuclear tests in the 1950s–1960s were deposited by glaciers. At present, they are released from the ice cap and are fixed on the glacier ablation zone by cryoconite holes at altitudes above 350–370 m a.s.l.

Rhine Salmon Population Threatened by Multiple Hurdles along Their Migration

Jacco Van Rijssel[1], Erwin Winter[1], Joep de Leeuw[1]
[1]Wageningen Marine Research, IJmuiden, Netherlands.

Introduction: Freshwater species biodiversity is under threat. The average global decline for migratory fish species is estimated to be more than 75% since 1970. Atlantic salmon is one of these species and has an estimated decline of 99% in the river Rhine. The causes for past decline have been posted to habitat loss, pollution, climate change and overfishing.

Objectives: The objectives of this paper are (1) to document the recent further decline, (2) estimate losses of smolts and adults at different sections in the freshwater habitat, and (3) elaborate on potential causes of the decline based on losses in different river sections and at sea.

Methods: Telemetry studies of downstream migrating smolts and upstream migrating adult salmon were used to estimate potential losses at different river sections and at sea. Additionally, we analysed stocking data, and published information on consumption by birds, fish and seals and bycatches in fisheries.

Results: We found that the salmon population of the river Rhine has declined rapidly over the past two decades with a current estimated spawning population of only 373-798 individuals. Far from the desired 3% supposedly needed to maintain a self-sustaining population, this equals a percentage of salmon returning to the spawning grounds of between 0.5-0.6%. Many individuals disappear during their migration, with the highest percentage of smolts disappearing in the German tributaries (44%) and the Dutch lower Rhine (71%) while the percentage of disappearing adults is highest in both the Dutch (74%) and the German (78%) Rhine.

Conclusion: Causes of the decline per river section remain unclear and possible threats, some specific to the river Rhine, are being discussed. Large losses of smolts and possibly adults could be caused by bird and fish predation in combination with migration obstacles such as weirs and turbines in the tributaries of the Rhine as anecdotal evidence suggests. To ensure that the highest number of wild smolts in the best condition leave the Rhine for the ocean, management needs to restore the ecological integrity of the Rhine system.

Large-Scale eDNA Metabarcoding Survey of Danube Fish Communities

Paul Meulenbroek[1], Thomas Hein[1], Tibor Erős[3], Alice Valentini[2], Michael Schabuss[4], Horst Zornig[4], Mirjana Lenhardt[5], Ladislav Pekarik[6], Pauline Jean[2], Tony Dejan[2], Andrea Funk[1], Didier Pont[7]
[1]Christian Doppler Laboratory for Meta Ecosystem Dynamics in Riverine Landscapes, Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources And Life Sciences, Vienna, Vienna, Austria.
[2]SPYGEN, Le Bourget du Lac, France.
[3]Balaton Limnological Research Institute, Tihany, Hungary.
[4]PRO FISCH OG, Vienna, Austria.
[5]Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia.
[6]Plant Science and Biodiversity Center, Slovak Academy of Sciences, Bratislava, Slovakia.
[7]Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences, Vienna, Austria.

For assessments of the population status of riverine fish species, time-limited systematic surveys are required, and quantitative monitoring of fish assemblages remains a difficult and costly task, particularly in large rivers. Consequently, novel and innovative techniques are required, especially in large rivers as the Danube in Europe, the world's most international river, draining the areas of 19 countries (>6400 m^3 s-1) and listed as one of the world's top 10 rivers at risk.

Restoring Nursery Habitats for Fishes in the Lower River Rhine

Leo Nagelkerke[1], Twan Stoffers[1], Antonie Buijse[1]
[1]Wageningen University & Research, Wageningen, The Netherlands.

Introduction: The large rivers of western Europe have been heavily modified, resulting in degraded natural processes and habitats. This also led to a severe decline of rheophilic fish species, typical for European lowland river systems, such as European barbel (Barbus barbus), nase (Chondrostoma nasus), and dace (Leuciscus leuciscus). To improve the ecological quality of these river systems, authorities in the Netherlands have initiated restoration projects in the floodplains of the lower Rhine River and its distributaries. In most cases restoration projects include either the one- or two-sided reconnection of existing floodplain channels, or the construction of new ones. The projects mostly led to positive changes in water quality and an increase in natural habitats, but not to the expected recovery of rheophilic fish species. Insufficient extent or quality of nursery habitats for juvenile fish could be one of the causes for the limited recovery of these fishes.

Objectives: Therefore, the main objective of this study was to achieve a better understanding of how restored floodplains function as nurseries for river fishes, leading to optimisation of ecological restoration projects and improving recruitment success of rheophilic fishes in the Rhine.

Methods: A large-scale field study was performed in 46 restored floodplains during four years (2017-2020), sampling habitat conditions and young-of-the-year (YOY) fish.

Results: We found that the nursery potential of restored floodplain channels is primarily determined by connectivity to the main channel and habitat heterogeneity. Two-sided connected floodplain channels contained most species and had a four times greater abundance of rheophilic species than one-sided connected channels. Also, there are considerable species-specific differences in preferred nursery habitat conditions, with e.g., nase, and dace favoring shallow habitats with slow-flowing water, and barbel preferring fast-flowing water. Moreover, young fish shift habitats in their first year, with substantial differences between species. Finally, in the river Rhine the efficacy of restoration projects as fish nurseries changes with time, with the highest rheophilic abundances in 10 to 15-year-old floodplain waters, but with species richness decreasing steadily with floodplain age. Sedimentation near the river-floodplain inlet, diminishing flowing conditions, was one of the primary driving forces causing this.

Conclusions: The main conclusions of this study are that suitable environmental conditions, of which water flow is dominant, need to be maintained, either naturally, or by human intervention, to retain a nursery function for fishes. Secondly, there is no "one-size-fits-all" design for restoration projects, since different restoration types can provide nursery habitat for different species. This is an argument for designing diverse restoration projects on the river scale.

Longitudinal Connectivity Changes and Migration Patterns of Potamodromous Fish

Johannes Kowal[1,2], Michael Grohmann[1], Andrea Funk[1,2], Günther Unfer[1], Gertrud Haidvogl[1], Thomas Hein[1,2]
[1]Institute of Hydrobiology and Aquatic Ecosystem Management (ihg), Vienna, Austria.
[2]WasserCluster Lunz, Lunz, Austria.

In central Europe and many other parts of the world rivers have commonly been subjected to severe human interferences. As a result, the aquatic flora and fauna is impacted by stressors such as morphological alterations, pollution or water abstraction. Therefore, the ecological resilience of the overall river meta-ecosystem increasingly depends on its interconnectedness in order to compensate for local habitat loss or degradation. However, the constructions of dams, hydraulic structures for navigation as well as flood protection measures have led to a severe fragmentation of most river networks. Only during the past 20 years, measures to improve the connectivity have been implemented. While continuum interruptions have to be considered as a four-dimensional stressor (longitudinal, lateral, vertical, temporal), we focus on the longitudinal dimension using the concept of the meta-ecosystem as a theoretical background. Here, we investigate both long-term changes and recent conditions, evaluating whether or not some of the ecological effects of river fragmentation and restoration measures can be quantified on the reach and catchment scale. For this purpose, we calculate and compare connectivity indices with parameters that reflect the ecological status of the fish fauna in the Austrian Danube and its tributaries. Many fish taxa act as highly suitable indicators for interruptions of the longitudinal continuum due to their mobility patterns while at the same time their dispersal pathways are almost exclusively located along the river network. In the Danube for example, several iconic species utilize a portfolio of seasonal migration patterns and hence depend on an intact river continuum. In the 21st century however, the Danube represents a largely fragmented system where those patterns remain mostly unknown but nevertheless bear the potential of shedding light on present as well as historic population sizes, structures and dynamics. In order to tackle those aspects, we use the PIT-technology to mark fish and apply different Capture-Mark-Recapture models to reduce uncertainties in abundance estimates with a special focus on barbel (Barbus barbus), bream (Abramis brama), nase (Chondrostoma nasus) and vimba (Vimba vimba). In addition, we aim to gain further insights through the installation of a large-scale PIT antenna monitoring system. In this way, our research tries to answer some of the fundamental questions necessary for the conservation and restoration of the Austrian Danube and its native fish fauna at larger scales.

Long-Term Fish Community Shifts and Rehabilitation of Rhine and Meuse

Joep J. De Leeuw[1]
[1]Wageningen Marine Research, Ijmuiden, Netherlands.

Introduction: The lower branches of the River Rhine and River Meuse, running through the most densely populated areas of Europe, have a long history of alterations owing to flood protection, shipping and water quality issues. Despite substantial water quality improvements and habitat restoration projects such as recreating side-channels and floodplain enhancement in recent decades, recovery of riverine fish communities is limited while unexpected shifts in fish communities occurred.

Objectives: The objectives of this research are (1) to document shits in fish communities over the past 30 years, (2) analyze the possible impact of relatively recent environmental perturbations such as climate change, invasive species, and habitat restoration on the developments in fish communities, (3) elaborate on potential robust management measures for future river rehabilitation.

Methods: We analyzed (1) 30 years of standardized annual fish surveys and time series of potential drivers (e.g., oligotrophication, climate-driven river discharge patterns, invasive species), and (2) some in-depth ecological studies on habitat alterations and habitat use of fishes in floodplain waters and side-channels, as well migration along main channels in the lower branches of the rivers Rhine and Meuse.

Results: Benthic fish species declined significantly, mainly owing to oligotrophication after gradual decreases in phosphate levels. Many rheophilic species declined as well, possibly because of climate-driven changes in river discharge patterns and because of strong increases of invasive Ponto Caspian gobiid species. Local reconstructions of floodplains and side-channels demonstrated enhancement of spawning and nursery functions for riverine fish.

Conclusion: River habitat rehabilitation measures show the potential of enhancing ecosystem functioning for riverine fish. However, the scale of these measurements so far could not counteract impacts of discharge patterns, invasive species and/or oligotrophication on ecosystem functioning at the scale of larger river sections. Large-scale floodplain restoration and increased connectivity of river tributaries to the main channel are discussed as further potential for rehabilitation of riverine fish communities.

Habitat Shifts Highlight the Importance of Heterogeneity in Fish Nurseries

Tom Buijse[1], Antonie Buijse[1], Leopold Nagelkerke[1]
[1]Wageningen University and Research, Wageningen, Netherlands.

Introduction: Large-scale anthropogenic modifications of rivers have resulted in the degradation or even total loss of important floodplain nursery habitats for riverine fishes, causing their populations to decline. In recent decades, many floodplains restoration projects have been implemented to recover these populations, with varying degrees of success. Understanding the habitat use of larval and juvenile fish in a heterogeneous environment is critical for improving the ecological efficacy of these projects.

Objectives: We aimed to identify the use of different nursery habitats by the young-of-the-year fish community as a whole and by individual species. Additionally, we aimed to assess the role of habitat heterogeneity in fish recruitment success. This knowledge can be used to optimize restored floodplain nursery areas in order to combat declining rheophilic fish populations and fish biodiversity in modified large lowland rivers.

Methods: We collected and analysed a unique data set of 2,238 sampling events in 18 restored floodplains over three growing seasons (2018-2020) to assess ontogenetic shifts in habitat use of young-of-the-year fishes in the lower river Rhine (the Netherlands). We identified five functional nursery habitats and analysed their use and availability throughout the growing season (April-September).

Results: Early in their ontogeny both eurytopic and rheophilic fishes preferred shallow slow-flowing and sheltered habitats. Thereafter eurytopics moved to deeper, sheltered habitats. Some rheophilic species (Chondrostoma nasus and Leuciscus leuciscus) also moved towards these deep-water habitats, while others (Leuciscus idus, Romanogobio belingi, and Barbus barbus) preferred residing in dynamic, fast-flowing habitats of the main channel. This habitat shifts typically occurred around a length of 50 mm for eurytopic and around 100 mm for rheophilic fishes. Within both guilds species-specific ontogenetic shifts were observed, highlighting the importance of habitat heterogeneity for a diverse fish community. Furthermore, the availability of required habitats varied greatly across growing seasons and restoration projects, which affected the ecological efficacy.

Conclusion: To combat declining riverine fish populations and biodiversity in modified large lowland rivers, we propose three restoration guidelines: (1) maintain permanent lateral connectivity between the restored floodplain and the main channel, (2) establish high levels of floodplain habitat heterogeneity throughout the growing season of riverine fishes, and (3) include deep water habitats that can act as refuge areas during extreme low discharges.

Monitoring: A Technical Approach for Long-Term Management of River Restoration and Conservation

Jennifer Lisa Insupp[1], Vanessa Berger[1], Daniel Dalton[1], Michael Jungmeier[1]
[1]UNESCO Chair on Sustainable Management of Conservation Areas - Carinthia University of Applied Sciences, Villach, Austria.

Almost all large rivers in North America and Europe have been modified, changed or constructed in some manner. This has led to degradation, sedimentation and decline in biodiversity (Campbell 2007). In recent years, the improved understanding of the importance of natural resources and the ecological impact of modifying these habitats has led to different approaches in river restoration and rehabilitation. Typically, only small stretches and certain river parts usually are renaturalized; however, these practices have stimulated many ideas and methods to integrate river management in a sustainable way (A.D. Buijse et al. 2005).
In the last two years a guideline outlining a suitable framework for monitoring biodiversity in protected areas and Other Effective Area-based Conservation Measures was created from the team headed by the UNESCO Chair on Sustainable Management of Conservation Areas. Long-term monitoring is a tool that managers can use to assess the success of conservation efforts and can demonstrate the impact of management actions. The guideline is a tool that can be further extended to river management and restoration efforts, helping to produce valuable knowledge on biodiversity conservation in large rivers. The guideline presents a step-by-step approach to consider all relevant details for biodiversity monitoring in conservation and key biodiversity areas and use current state-of-the-art monitoring tools. The easily understandable work flow is divided in four phases: 1) preparatory phase, 2) conceptual phase; 3) implementation phase with periodic interim evaluation guiding adaptive management; and 4) periodic re-evaluation of the monitoring program (Dalton et al. 2023).
Together with partners, experts, and stakeholders, a statement of purpose is developed following a review of available site background information, which will help direct the following next steps. A monitoring concept worksheet is developed in the conceptual phase, which plays a key role to generate a field manual for implementation of the monitoring program. These steps allow crucial questions to be assessed, helping managers to focus on the important aspects of the monitoring program and to give the biodiversity monitoring system a necessary structure (Dalton et al. 2023).
With this combined knowledge the monitoring framework can be a relevant component to river restoration and biodiversity improvement, which can be shared with all stakeholders that are involved with management and modelling tasks.
Since conventional approaches have seriously endangered water bodies, new sustainable and cost-effective alternatives have become crucial for river management (Rowiński et al. 2018), and this is where the monitoring guideline can be of vital importance.

Seasonal Plankton-Dynamics in a Free-Flowing Section of The Ob River

Liubov V. Yanygina[1], Olga S. Burmistrova[1], Anton V. Kotovshchikov[1], Martin Schletterer[2]
[1]Institute for Water and Environmental Problems SB RAS, Molodezhnaya St. 1, 656038 Barnaul, Russian Federation, Barnaul, Russian Federation.
[2]Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sci-ences, Vienna (BOKU), Gregor-Mendel-Straße 33, 1180 Vienna, Austria.

Introduction: Free-flowing (unregulated) sections of large rivers are characterized by significant seasonal and interannual variability of hydrological conditions, which causes significant variability of biotic communities. The Ob is the 7th longest river in the world, its length (with Irtysh) is 5,410 km and its catchment area is approximately 2,990,000 km². The river is regulated by a dam built above the Novosibirsk, which significantly reduced the amplitudes of seasonal changes in the water level downstream. In the area above the reservoir, two peaks of water level rise are observed, corresponding to snow melting in the flat part of the catchment and in the mountains and reaching 7 m (at Barnaul) in some years.

Objectives: We assumed that the seasonal dynamics of phytoplankton and zooplankton in the Ob River differ due to differences in factors limiting the development of each community. To assess the factors controlling the seasonal dynamics of plankton, we conducted this study of the Ob River near Barnaul in 2013-2018 and 2020-2021.

Methods: Plankton samples were collected 2-4 times a month during the open water and 2-3 times during the ice-covered period. Sampling was carried out at the 234th km of the river Ob (from the confluence of Biya and Katun) at the city of Barnaul. Concurrently with plankton sampling water temperature, turbidity, conductivity, total dissolved solids, pH and oxygen were measured with a multiparameter-water-quality-sonde YSI 6600. Daily water level and discharge was measured at the gauge located 500 m below the sampling site.

Results: The results of the study showed that the seasonal dynamics of zooplankton and phytoplankton (according to the concentration of chlorophyll a in water) have different seasonal dynamics. The number of zooplankton in the river was determined by the arrival of organisms from the floodplain and sharply increased with a decrease in the water level during flood. The number of meroplankton (mainly larvae of the first stages of macroinvertebrates) was maximal immediately after the release of the river from ice. The seasonal dynamics of phytoplankton usually had two maximum: in summer (July-August) and in autumn (September) and was closely related to the water temperature during the summer-autumn low water, as well as with transparency during flood and autumn low water.

Conclusion: Despite the cohabitation in the water column and passive transfer with the current, drivers of the seasonal dynamics of phytoplankton and zooplankton in the Ob River differ. While conditions in the filled floodplain are more important for zooplankton, the amount of phytoplankton depends on the conditions in the main channel. Our research demonstrates the need for weekly sampling and combined analysis of hydrological and hydrobiological to understand the seasonal dynamics of ecosystems and predictions their changes.

Planning and Execution of Sensor Fish Deployments at Xayaburi HPP

Maria Collins[1], Thanasak Poomchaivej[2], Wayne Robinson[3], Lee Baumgartner[3], Pedro Romero-Gomez[1]
[1]Research and Development Department, ANDRITZ Hydro GmbH., Linz, Austria.
[2]CK Power Public Company Limited., Bangkok, Thailand.
[3]Institute for Land, Water and Society, Charles Sturt University, Albury, Australia.

Introduction: Fish protection has taken a central stage in view of the planned development of hydropower facilities in the Mekong River system. Fish biologists and environmental scientists have pointed out that a hydraulic characterization of fish passage conditions (e.g., with sensors) through operating turbines should ideally precede direct fish survival assessments (e.g., with live fish samples passed through turbines). The present work describes the planning and execution of a field campaign with Sensor Fish (SF, developed at the Pacific Northwest National Laboratory) to quantify key hydraulic stressors through turbine flows in the Xayaburi Hydroelectric Power Plant.

Objective: The goal of this work is to share our experience and inform other managers and engineers who may consider similar experiments in hydropower stations located in large rivers.

Methods: The interrogated unit was a Kaplan-type turbine of 8.6-m diameter and 185 MW rated output. The SF recorded time series of absolute pressure, accelerations and rotational velocities during passage, which were later interpreted to identify hydraulic events that affect fish survival. Because turbine dimensions made SF releases very challenging, a dummy sensor testing was necessary to validate the deployment/recovery process before costly active sensors were released. We describe herein general features of the release apparatus and the equipment used. Thereafter, we present a summary of the SF data analysis and its relevance for posterior evaluation of the biological effects of turbine passage. A highlight of our study consists of the examination of the influence of the sensor release location (two elevations) on measured hydraulic stressors. The tested release elevations represent potential fish entry into the turbine flow, an aspect that is known to be of relevance for the likelihood of survival.

Results: The SF measurements shed light on the strong influence of release elevation on the pressure conditions fish experience while passing large Kaplan turbines in operations (a difference in nadir pressures was approximately 40 kPa between SF samples). All nadir pressure remain above atmospheric conditions. The occurrence of collision on the runner was below 10% from both samples and did not show sensitivity to release elevation. Experience shows that some collisions lead to mortal bodily injury while other do not. The tendency for rotation in the draft tube did not show sensitivity to release elevation either.

Conclusions: In seeking to characterize the passage conditions for migratory fish in large rivers, HPP managers and participating engineers must be accurately informed about the logistic challenges that arise during the planning and execution of the SF deployments. The present work intents to provide such information by describing the related work undertaking at the Xayaburi HPP.

Microplastic Retention by Lagoons Surrounded by Vegetation in Wetland Areas

Mirco Mancini[2], Teresa Serra[1], Jordi Colomer[1], Luca Solari[2]
[1]University Of Girona, Girona, Spain.
[2]University of Florence, Florence, Italy.

In the last 70 years the production of plastic has raised exponentially (Ostle et al., 2019). The plastic production has caused the accumulation of plastics and microplastics (<5mm) in environmental ecosystems being a source of pollution in the atmosphere (Habibi et al., 2022), water (Zhang, 2017) and sediments (Abidli et al., 2018). The knowledge of the distribution of microplastics represents an unprecedented challenge. The assessment of possible hotspots where they can accumulate might give information on the potential areas that can require further attention and management to prevent these hotspots act as new microplastic sources. Microplastic particles pollute seawater (oceans and seas) and freshwaters (rivers, lakes). Wetlands are transitional areas between land and sea that can act as buffer for microplastic particles. In the current study, the impact of a lagoon surrounded by emergent aquatic vegetation characteristic of a wetland area is under study in a laboratory set-up. A lagoon has been constructed in a flume dominated by a unidirectional flow. The lagoon is surrounded by emergent aquatic vegetation (Juncus maritimus) with different patch lengths, L_{patch}. Considering that in natural environments microplastic particles are expected to be in suspension together with sediment particles, in the current study microplastics are injected at the entrance of the flume together with suspended sediment particles. Four different L_{patch} were considered and compared with the non-vegetation case and the no-lagoon case. 22 sediment traps where set on the bed of the flume at different positions along the x-axis. Four different microplastics were considered (PET-fibres of 6 mm o length×45 µm of diameter, PET-fibres of 3 mm o length×45 µm of diameter, PA-fragments in the range of 125 µm to 500 µm and PA-fragments in the size range of 500 µm to 1000 µm), accounting for a total of 22 experiments. Results for non-vegetated cases demonstrate that the major percentage of microplastic particles settled along the flume at distances, $L_{deposit}$, that depended on the settling velocity of microplastics. Also, aquatic vegetation increased the retention of microplastics compared with non-vegetated cases decreasing the distance $L_{deposit}$. The lagoon increased the retention of fine particles that were not expected to settle in the shallow zone. In summary, the presence of deep zones (lagoons) and aquatic vegetation in wetlands act as buffers for microplastic particles that are advected to the ecosystem by sediment particle laden currents. They play differential roles in the distribution of microplastic particles producing a segregation that depends on the characteristics of the particles being transported and the length L_{patch}.

Hydro-Geomorphic Perspectives on Microplastic Transport in The Rhine River

David Range[1], Thomas Hoffmann[1]
[1]Bundesanstalt für Gewässerkunde, Koblenz, Germany.

Introduction: Microplastics (MP) are constantly transported into the oceans via rivers. However, transport paths linking MP sources and sinks in the environment are insufficiently understood. For a quantification of riverine MP transport, knowledge on the linkages between MP and natural sediments is essential. Both underlie the same hydrodynamic forces, namely gravity, buoyancy and drag force. MP, as a highly heterogeneous mixture of solid particles, enhances the complexity of suspended matter with a vast spectrum of e.g., densities, compared to natural sediments. As the quantification of fluvial sediment transport is a well-established field of research, adopting existing knowledge to the quantification of fluvial MP transport is crucial.

Objectives: The main objective of our research is the development, application and comparison of sampling techniques to obtain information on spatial and temporal variability of MP in the Rhine River, which is aimed to result in a mass-based load estimation of the MP transport.

Methods: For an estimation of temporal variability in form of a MP-discharge relationship, manta nets and a continuous flow centrifuge at a single sampling site at Koblenz were used during different flow conditions. Considering the spatial variability, a net construction was built. From a vessel, a cross-section was sampled at three vertical profiles including three sample depths. This campaign was performed during low and mean water levels.
At three sites (Weil am Rhein, Coblenz and Emmerich) a continuous monitoring setup is constantly pumping river water through sedimentation boxes with a monthly sample collection. Hereby, information on the temporal variation, and, on a larger scale, on the spatial variation for the German section of the Rhine River is gathered. For the analysis of the collected samples, thermal degradation techniques (Pyr-GC-MS) and optical techniques (ATR FT-IR) are applied and units are given as MP masses for each size fraction.

Results: Preliminary results show that a positive relationship between MP concentration and river discharge is likely and temporal variability plays a large role in riverine MP transport. First results of the sampling campaigns indicate a heterogeneous distribution of MP a) at various depths and b) along the sampled cross-section of the Rhine River, often but not necessarily following polymer densities.

Vertical Distribution of Riverine Macro- and Mesoplastics

Stephanie Oswald[1], Frank Collas[1]
[1]Radboud University, Nijmegen, Netherlands.

Plastic pollution has been considered one of the major contemporary environmental challenges. Even though environmental effects associated with plastic pollution have been largely known, research on plastic concentrations mainly focuses on the marine environment. In recent years, an increasing number of studies reported environmental consequences and concentrations of plastic particles in freshwater systems comparable to those found in marine ecosyste The magnitude of plastic particles abundance in ecosystems may be influenced by factors other than the real presence of plastics in the aquatic environment, such as sampling methods, and identification processes. The lack of standardized procedures could result in an inconsistent data, limiting the comparison of plastic abundance across studies worldwide. Additionally, plastic properties such as size, density, and shape along with hydrological processes can affect the extent of plastic transportation in the water column. Therefore, in this study, two different sampling methods were performed. This project aimed to determine the depth variation in the concentration and composition of macro- and mesoplastic items in the water column of the river Rhine in the Netherlands. Samples were taken using a trawl net and a larvae net, both methods consisted of three separate nets positioned at different depths in the water column of the river. Results show a similarity in the relative abundance of the OSPAR categories of the collected plastic with the trawl net and the larvae net. For both methods, the most common category of macro- and mesoplastic found was “Undefined pieces of plastic film”. However, there is a difference between the number of categories collected between the methods, the trawl net collected relatively more categories than the larvae net. Near the bottom of the river, significantly higher concentrations were observed compared to the middle and surface layer of the water column. Understanding the concentrations and types of plastic in freshwater systems is relevant to assisting decision makers in the development of targeted measures and mitigation strategies.

Lessons Learn from a Co-Design in a Big River Basin

Carmel Pollino[1], Ross Thompson[2]
[1]CSIRO, Canberra, Australia.
[2]University of Canberra, Canberra, Australia.

The Murray-Darling Basin (MDB) in eastern Australia spans over 1 million square kilometers, covering much of eastern Australia. It is the largest river system in Australia and one of the largest in the world. The Murray-Darling Basin Plan (2012) represents a $13 million investment in water reform. It establishes a framework for the sustainable use of water resources in the basin, with a focus on improving the health of rivers and wetlands, reducing water consumption, and ensuring that water is allocated fairly and transparently among stakeholders. The plan sets water recovery targets to reduce the amount of water taken from the basin for irrigation, establishing the allocation of water for environmental purposes and the protection of important ecological sites and species. Over 2000 gigalitres have been recovered for environmental processes.

In 2012, a monitoring, research and evaluation (MER) program commenced to help to inform decision-making around water management practices and ensure that environmental water is used effectively to support the health of the basin's ecosyste This program of work established a series of Area- based monitoring sites, key Theme based on environmental outcomes, and a Basin-scale evaluation and reporting mechanism to synthesize outcomes. In 2021, a collaborative design process was undertaken to develop recommendations for the future of the MER activities for the MDB. Collaborative design (or co-design) is frequently used in program design as it is more effective and inclusive in establishing the design of outcomes, whilst fostering innovation, engagement, and greater communication.

The collaborative design process was implemented through a series of virtual engagement workshops, where the design options for the Program were defined. The engagement process included over one hundred people. The engagement activities drew upon knowledge from scientists from across Australia, environmental water managers from within the MDB, policy makers and representatives of First Nations bodies.

The recommendations for the design of the future MER program included: taking into account: lessons learnt from the existing MER Program; maintaining science quality and rigour to underpin trust; incorporation of indigenous science and knowledge into the Program; improved data and knowledge sharing; new technologies for monitoring; digital technologies for reporting; and building a knowledge base to better understand the impacts of climate change.

In this paper, we reflect on: the shifts in drivers in the design of the 2012 MER Program, relative to the 2021; the differing objectives across engagement groups; the barriers and enablers to designing a complex program which crosses the science and policy interface; and recommendations for future collaborative design projects.

Research To Inform Climate Adaptation in The Murray-Darling Basin, Australia

David Post[1]
[1]CSIRO, Canberra, Australia.

The Murray-Darling Basin in south-eastern Australia is one of the world’s largest rivers, draining an area of just over 1 million square kilometers. The basin drains about one-seventh of the Australian land mass and is the 16th longest river in the world. However, being located on the driest continent on Earth, its discharge is relatively small, averaging just 767 m^3/s, far smaller than the discharge from any other similarly sized river worldwide.

Despite the relative lack of water, the Murray-Darling Basin is one of the most significant agricultural areas in Australia. In order to manage the water in the basin, in 2008 the Murray-Darling Basin Authority was formed with a mandate to manage the Murray-Darling Basin in an integrated and sustainable manner. Water reform in the basin has been a world-first in terms of the scale of intervention, but it has led to numerous conflicts in terms of access to water. The ability to manage the basin adequately relies on appropriate research being carried out in order to determine how much water is currently available, where it is currently being used, and how water availability and use are likely to change into the future.

Like much of southern Australia, the Murray-Darling Basin is already feeling the impacts of climate change, with more hotter days, fewer cold days, and a reduction in cool-season precipitation. These changes are only likely to increase over the coming decades and adaptation options to ameliorate negative impacts are required.

Additionally, the Murray-Darling Basin Plan which was brought into force in 2012 is due for evaluation in 2025 and review in 2026. CSIRO is carrying out research across multiple disciplines in order to assist in this evaluation and review.

This presentation will summarize the research being carried out by CSIRO in order to assist the Murray-Darling Basin Authority to appropriately manage the water resources of the basin.

How Can Renewables Relieve the Dam-Building Pressure on African Rivers?

Rebecca Peters[1], Jürgen Berlekamp[1], Beth A. Kaplin[1], Klement Tockner, Christiane Zarfl[1]
[1]University Of Tuebingen, Tuebingen, Germany.

Mitigating climate change, while human population and economy are growing globally, requires a bold shift to renewable energy (RE) resources. In Africa, the need for this transition is accompanied by the urgency to “ensure access to affordable, reliable, sustainable, and modern energy for all” (Sustainable Development Goal (SDG) 7) for almost half of the African human population that currently lacks access. At state, hydropower is still the main RE technique implemented in Africa. It is broadly studied that hydropower plants (HPP) operating with reservoir storage and dam can cause ecological, socioeconomic, and political ramifications on different spatiotemporal scales. Planned HPP and other dam-related infrastructure increasingly disturb Africa’s River systems and threaten biodiversity hotspots. Declining costs for solar PV (90% decline since 2009) and wind turbines (55-60% decline since 2010) have led to increasing growth rates for solar (SPP) and wind power plant (WPP) implementation. In addition, the use of complementary spatiotemporal properties of RE resources via hybrid plants, e. g. the combination of variable power from SPP and WPP with storage capacity from existing HPP, minimizes the need for new hydropower infrastructure and related ramifications. While it is widely discussed that Africa could leapfrog a renewable energy transition, spatially explicit studies on the combination of hydro-, wind, and solar power, its potential in different African countries, and the respective meaning for river systems prone to hydropower implementation are missing. Thus, the aims of this study were to (1) assess impacts of proposed HPP on ecological and social indicators and identify the most critical projects, (2) estimate to which degree these critical HPP could be replaced by SPP and WPP when their full potential would be exploited, and (3) analyze the potential for hybrid plants, i.e., solar and wind in combination with (existing) HPP. We used data from RePP Africa, a new georeferenced database on existing and proposed hydro-, wind, and solar power plants, calculated river fragmentation and future reservoir areas and used the latter with data on settlement, land use, megafauna, sedimentation, potential evaporation, and protected areas to perform an integrated impact assessment for hydropower plants on a catchment scale with ArcGIS. The all-Africa dataset of energy model supply regions for solar photovoltaic and wind power published by Sterl et al. (2022) was used to estimate solar and wind potential. Our results elucidate how Africa can realize a RE transition that accounts for river protection. This study provides quantitative, data-based, and spatially explicit insights on the status and projections for the implementation of a renewable energy mix that could relieve the dam building pressure on rivers in Africa.

Integrated Monitoring and Evaluation of Pilot with Longitudinal Training Walls

Tom Buijse[1,3], Erik Mosselman[1,2], Henk Eerden[5], Frank Collas[4,5], Laura Verbrugge[4,6], Andries Paarlberg[7], Amgad Omer[1], Jurjen de Jong[1,8], Víctor Chavarrías[1], Willem Ottevanger[1], Rolien van der Mark[1], Remi van der Wijk[1], Nathalie Asselman[1]
[1]Deltares, DELFT, Netherlands.
[2]Delft University of Technology, DELFT, Netherlands.
[3]Wageningen University, Wageningen, Netherlands.
[4]Radboud University, Nijmegen, Netherlands.
[5]Rijkswaterstaat, Arnhem, Netherlands.
[6]Aalto University, Aalto, Finland.
[7]HKV Consultants, Lelystad, Netherlands.
[8]Sweco, Stockholm, Sweden.

The river Waal is the main branch of the river Rhine in the delta in the Netherlands. It has been trained with groynes in the 19th century to reduce flooding risk due to ice jams and to improve navigability. The resulting narrower main channel, however, has triggered bed erosion and lowered low-flow water levels at a rate of meters per century with increasing adverse effects. For instance, hydraulic structures become unstable, pipeline and cable crossings are exposed, obstacles appear for navigation, and inundation depths and frequencies of floodplain and wetland habitats are reduced. To mitigate the adverse effects while maintaining the benefits of river training, Rijkswaterstaat launched the idea of a new system of river training. It replaces the existing system of a single main channel between groynes by two parallel channels, separated by a longitudinal training wall. To test this new system, Rijkswaterstaat implemented a 10-km long pilot with three longitudinal training walls in the river Waal in the years 2014-16. Before, during and after implementation, an extensive monitoring and research program was executed by the Waal Samen partnership consisting of Rijkswaterstaat, Koninklijke BLN-Schuttevaer, Sportvisserij Nederland, Hengelsportfederatie Midden-Nederland, Deltares, and the universities of Nijmegen, Wageningen, Delft and Twente. The new system was found to improve navigability at low flows if applied in reaches of least available depth. Moreover, it was found to sustain long-term navigability by countering the ongoing overall incision of the river bed. After implementation of the pilot, the waterway continued satisfying the international navigability standards. The pilot substantially improved the quality of nature in the reach of the training walls. The walls lowered design flood water levels at least as much as the groyne lowering previously planned in this reach. A modestly positive effect was found on freshwater supply during droughts. Participation of stakeholders in the monitoring and research program was found to have increased support and appreciation for the pilot. We conclude that the system tested in the pilot opens perspectives for integral solution of several river proble It performs better than the old system with groynes thanks to spatial diversification through separation of functions. No unforeseen negative impacts have surfaced. A longer pilot reach monitored over a longer period would be required for solid conclusions about the extent to which the new system solves all river problems, but at any rate it offers more space for further improvements in the future than the old system. Rijkswaterstaat and Deltares jointly identified three points of further attention: (i) regulation of flow and sediment transport by modifying inlet sills; (ii) operation and maintenance; (iii) the inland waterway. We recommend addressing these points by continued monitoring and close consultation of the inland waterway transport sector.

The Arctic Mouth Hydrology: History of Monitoring

Nadezhda Kharlampeva[1], Mikhail Tretyakov[1]
[1]Associate Professor, Senior researcher, Arctic and Antarctic Research Institute, St.Petersburg, Russian Federation.

History of formation and basics of development of the Arctic Mouth Hydrology science field of Arctic and Antarctic research institute (AARI) is one of perspective monitoring system structure of the Arctic ecosystem.
Objective is process of shaping of the Arctic Mouth Hydrology monitoring scientific direction of AARI
Research method: systematization of the Arctic Mouth Hydrology bibliography since 1920 till present time: identification of organizational bases of monitoring system according to structural and functional analyze of the Arctic Mouth Hydrology's scientific activity in main large rivers of the Russian Arctic.
Results. The history of shaping the Arctic Mouth Hydrology scientific direction of AARI is given in seven stages (1925- present time): transformation of the water issues management; description of the lower reaches and mouth of the main rivers, the organization of polar stations in the Russian Arctic; providing navigation with icing hydrological forecast on the North Sea Route and project development for the fundamental improvement of navigable conditions at estuarine bars and Siberian and North-East of the Russian Arctic largemouth rivers; contribution of the Arctic Mouth Hydrology to the International Hydrology Decade; the Department of the Arctic Mouth Hydrology and Water Resources (AMH and WR) as a main unit of AARI; the Arctic Mouth Hydrology scientific direction to an abiotic component in Arctic aquatic systems; elaboration of the AMH and WR Department to the system-wide integrated water management projects development for surface water bodies monitoring of the Arctic.
Conclusion. Prospect of the Arctic Mouth Hydrology and Water Resources of AARI scientific direction in the coming years relate to scientific research development on the methods and technologies design for operational hydrological forecasts, research on the water balance and water resources, the surface waters space monitoring in the Arctic, including mouth rivers basin region of large rivers and water bodies in scientific inpatient facilities of the AARI and their changes under the influence of natural and anthropogenic factors their diagnosis, calculation and forecasting, as well as continuing to participate in improving socio-ecological approach and international expertise activity. The next tasks of the Arctic Hydrology will undoubtedly be the fulfillment of state monitoring of the Arctic water resources, their protection and rational use, combining knowledge of social and natural sciences concerning water resources to satisfy the interest of society.

Web Based River Models to Inform Development in Northern Australia

Justin Hughes, Lynn Seo[1], Danial Stratford[1], Cuan Petheram[1]
[1]CSIRO, Canberra, Australia.

River system models are a fundamental tool for the exploration of river system behavior when subject to changes such as development (e.g., irrigation diversion), and how changes in river management will affect all water users including environmental assets.
In Australia, access to calibrated river system models has been limited to state and territory hydrologists and selected consultants. Other stakeholders are generally unable to access river system models due to a lack of technical knowledge, computational and software license restrictions as well as a general reluctance by government to make such tools readily available.
We present a web based river system model that was developed as a part of the Northern Australia Water Resource Assessment (NAWRA), an initiative of the Australian government to understand the opportunity for, and associated risks, of water based development in northern Australia. The model and interface are unique, in that it provides a level of transparency related to water resources and development effects that was hitherto unknown.
The web based model (NAWRA-river) allows users to run daily river system model simulations for multiple nodes (locations) across an entire river system, in both the undeveloped state, and with development scenarios defined by the user. Simulations can be run for over 100 years allowing longer term assessment of development effects.
Development options in model nodes are of either in-stream or off stream reservoir design. Users can specify various parameters such as reservoir size, volumetric allocation limits, pump capacity (off-stream reservoirs), river flow rate pump start thresholds (off-stream reservoirs). These scenarios can be run in multiple nodes simultaneously and be of unique design in each node.
The model runs the user defined scenarios in real time and various metrics and plots are generated that allow comparison to the undeveloped state. Reliability of supply is defined in each node where a development scenario is specified. The model also features an assessment of various ecosystem metrics in each node for both undeveloped and development scenarios which can help define the tradeoff between diversion and ecosystem health.

Restoring Europe's Large Rivers for Nature and Society

Sebastian Birk[1], Tom Buijse[2], Gertjan Geerling[2], Thomas Hein[3], Silke-Silvia Drexler[3], Tibor Erős[6], Andreas Anlauf[5], Michael Gerisch[5], Elmar Fuchs[5], Marieke de Lange[7], Joost Backx[7], Alice Kaufmann[4], Robert Tögel[4], Peter Kajner[8], Tamas Gruber[8], Albert Scrieciu[10], Camelia Ionescu[9], Florian Leischner[1], Daniel Hering[1]
[1]University of Duisburg-Essen, Essen, Germany.
[2]DELTATES, Delft, the Netherlands.
[3]BOKU, Vienna, Austria.
[4]Viadonau, Vienna, Austria.
[5]Bundesanstalt für Gewässerkunde, Koblenz, Germany.
[6]BKLI, Tihany, Hungary,
[7]RWS, Lelystad, the Netherlands.
[8]WWF HU, Budapest, Hungary,
[9]WWF RO, Bucharest, Romania.
[10]GEOECOMAR, Bucharest, Romania.

Europe‘s environment is in an alarming state, with climate change effects aggravating. To secure economic prosperity, human wellbeing and social peace, systemic transformative change of our society is imperative. Ecosystem restoration using nature-based solutions (NbS) is key to this change, in which freshwaters hold a pivotal role. The EU Green Deal innovation project MERLIN demonstrates freshwater restoration best-practice that implements innovative NbS at landscape-scale. The project’s ambition is to upscale systemic restoration, seizing opportunities for green growth and private investment into restoration. MERLIN capitalises on 17 successful freshwater restoration projects across Europe, including large transboundary rivers. With investments of 10 mio Euro in hands-on upscaling measures along scalability plans, MERLIN transforms these projects into beacons of innovation for systemic change. MERLIN‘s initiatives aim at co-designing win-win solutions with economic sectors (e.g., agriculture, water supply, insurance, navigation) and local communities, spearheading systemic economic, social and environmental change. MERLIN is committed to a sustainable, climate-neutral and -resilient, inclusive and transformative path, mainstreaming restoration as a cornerstone for systemic change. The talk will provide an overview of the MERLIN project with a focus on large transboundary rivers, and summarizes the project status in its first two years of implementation.

Rhône Sediment Management Master Plan between Geneva and Mediterranean Sea

Frederic Laval[1]
[1]Ginger-burgeap, Saint Martin D'heres, France.

The study leading to the Rhône Sediment Management Master Plan between Lake Geneva and the Mediterranean Sea, carried out by a DREAL / CNR / EDF / Water Agency partnership, was finalized in July 2022. This is the outcome of a long process of compiling and summarizing technical, scientific and social data in order to guide management and restoration measures for the river and reach 2027-2050 objectives. These objectives are organized into 3 categories: biodiversity, safety-security, socio-economics. Biodiversity objectives are especially linked to the achievement of the good ecological status and potential according to WFD. Safety-security objectives deals with the safety of dams and the security of the populations against flood envents. The sustainability of the socio-economic uses concern navigation, hydroelectric plants, nuclear power plants, drinking water production, irrigation and leisure activities.
The study valued and completed the works of the Rhône Scientific Observatory of Sediment (OSR4-5 Program). The sedimentary fluxes of the Rhône have been updated, showing a good continuum for silt and sand, whereas bedload continuity is strongly affected by impoundments and run-of-the-river da Sediment balances has been established over the last four decades and identify degraded and aggraded reaches.
At the same time, the sedimentary contributions of the tributaries were estimated from existing watershed studies and dredging operations carried out at the confluences; the future trends of these inputs - stability, drying up or return of sediments - have been analysed, in connection with climate change and the role of implementations in these catchment areas.
Feedback from the past actions shows that for 25 years (from 1995 to 2018), nearly 300 sites have been the subject of management interventions by dredging, with 850,000 m³/year on average. Flushing and sluicing dams complete the management measures. At the same time, the Rhône and its hydrosystem has been restored on around 150 sites: increase of biological flows, restoration of around 80 secondary arms, reactivation of alluvial margins, and sedimentary reinjections since a few years.
The means for the master plan, focusing on the previous objectives, are based on key actions, including innovative actions such as coarse sediment nourishment or morphogeneous flows. These actions must lead to better continuities for coarse sediments. The operational objective is to gradually increase the annual reinjected volume from 40,000 m³ over 1995-2018 to around 200,000 m³/year by 2030-2035, giving priority to by-passed reaches (Old Rhône), with high ecological value and needing to be resilient to climate change. The strategic orientations are formulated along major sectors and are accompanied by recommendations, technical toolboxes, factsheets, etc. in order to accelerate and improve the operational implementation. In 2023, the master plan will be discussed by the Rhône basin committee in order to be definitively adopted.

River Science Is Supported by Long-Term Research: The Example REFCOND_Volga

Martin Schletterer[1,2], Vyacheslav V. Kuzovlev[3,4]
[1]University of Natural Resources and Life Sciences, Vienna, Innsbruck, Austria.
[2]TIWAG - Tiroler Wasserkraft AG, Innsbruck, Austria.
[3]Tver State Technical University, Tver, Russian Federation.
[4]Tver Center for Hydrometeorology and Environmental Monitoring (ROSHYDROMET), Tver, Russian Federation.

River science is a “rapidly developing interdisciplinary field at the interface of the natural sciences, engineering and socio-political sciences” (sensu Gilvear et al. 2016). Water management needs to take into account the 4d nature (longitudinal, lateral, vertical and temporal scale) of river ecosystems, and nowadays we also need to consider a fifth dimension the “human uses”. In this contect, management decisions should be based on sound monitoring data, because this supports sustainable management. Thus, basic ecological research is needed at reference sites in order to analyze the occurring natural variation (process understanding).
Our LTERM project REFCOND_VOLGA is operated continuously since 2006, with the aim to analyze the inter-annual variation at reference or least disturbed sites along the Upper Volga and it`s tributary Tudovka. The free-flowing section between the Upper Volga Lakes and Tver comprises an important reference section for lowland rivers. Our limnological assessment includes classical (cartometric, hydrometric, hydrochemical and biological analysis) and innovative approaches (e.g., eDNA and remote sensing).
The results demonstrate how lowland rivers are characterized by their biota, integrating abiotic (hydrology, temperature regime, substrate, catchment conditions) and biotic (ecological preferences, “keystone / flagship spp.”) factors. Long-term monitoring is the only way to analyze variations as well as effects of rising air and subsequently water temperatures (related to climate change) on aquatic biota. However, we also exemplify challenges for long term ecological research and monitoring and summarize the effects of the COVID-19 pandemic on field science and international collaboration.
Overall, the Water Framework Directive defined targets for all European surface waters and stipulated an integrative planning process. Long term datasets can also help to identify and develop sustainable measures. In conclusion, “best practice solutions” can only be achieved with international collaboration and a combination of basic and applied research.

Inventory and Outlook of Sediment Research in the Rhine Catchment

Michael Krapesch[1], Mario Klösch[1], Wilfried ten Brinke[2], Helmut Habersack[1]
[1]University of Natural Resources and Life Sciences, Vienna, Vienna, Austria.
[2]Blueland Consultancy, Utrecht, The Netherlands.

Introduction: The Rhine River was subject to intensive human interventions in the 19th and 20th century. These measures affected the flow and especially the sediment transport dramatically by increasing the sediment transport capacity and reducing the sediment input at the same time. Consequently, this sediment imbalance resulted in a comprehensive degradation of river morphology and ecology.

Objectives: To improve our understanding of the morphological and ecological situation in the Rhine Catchment, the International Commission for the Hydrology of the Rhine Basin (CHR) initiated the present study in 2020. The objectives of the study were to (i) present a catchment-wide overview of sediment-related issues in the Rhine and its tributaries, (ii) outline research and monitoring activities, (iii) identify existing knowledge gaps, and (iv) propose a future research program at the catchment scale.

Methods: The methodological approach was based on a comprehensive literature review on sediment-related issues and activities in the Rhine Catchment. Moreover, experts from six riparian countries dealing with sediment research were interviewed to get more insights into sediment-related issues, sediment management activities and knowledge gaps, and into monitoring strategies.

Results: The disturbed sediment continuity was recognized as one of the major problems in the Rhine Catchment, which results from Lake Constance acting as a natural sediment trap and from several dams in the main stream and in the upstream tributaries. The retention of bedload in the impounded section caused riverbed erosion in the free-flowing section in Germany while in the upper delta in the Netherlands, the input of fine material and the inundation frequency of floodplains decreased. In the lower delta near Rotterdam, tidal currents are causing deep scour holes locally and the intrusion of salt water further upstream.
The present study showed that current research activities focus on river restoration and flood protection. Current measures try to increase the bedload continuity by e.g., gravel nourishments. In the delta section, research projects address issues in relation to bed degradation and the fine material budget resulting from processes like changes of the discharge regime.
To fill existing knowledge gaps, future research should focus, for example, on the investigation of the main drivers affecting morphology and sediment transport, and the impact of climate change and land-use change on the sediment regime.
Current strategies for monitoring sediment transport and bathymetry strongly vary along the Rhine and should therefore be harmonized to make information more comparable.

Development of City River Management Platform in the Smart City

Bon Hyun Koo[1], Taeyoung Ham[1], Eunjeong Lee[1], Kyucheoul Shim[1]
[1]Institute of Smart Disaster Management, JBT Corporation, Seoul, South Korea.

Most of the smart cities are developing around rivers. Therefore, many disasters can occur in relation to water, so the importance of management and analysis of water resources is increasing. Heavy rains and torrential rains, which occur frequently in recent years, sometimes cause various problems such as river overflow and runoff in cities. In order to solve this problem, a platform that can collect various information related to rivers and climate and analyze floods from upstream of rivers to inside cities is needed. In this study, we developed an urban city river management platform. The platform is automatically collecting data on the web and providing the analyzed information by performing flood analysis based on the collected information to effectively perform smart city river management. The platform was analyzed and tested in the Eco Delta City (EDC) area, Busan, Korea. In order to analyze the runoff in the EDC area, observation information such as rainfall, facilities, water level and tide level related to the entire watershed was automatically collected from various distributed systems using OpenAPI. In this platform, in order to analyze from the upstream of the river to the outflow in the city, a watershed runoff analysis model, a river flow analysis model and an urban runoff analysis model were applied. GeoCRP can obtain more reliable results by taking a step-by-step approach to urban overflow that may occur in smart cities through the applied model. In addition, since all analysis processes such as data collection, input data generation and result data storage are automatically performed on the web, analysis can be performed, and results can be viewed if an environment that can access the web is established without special equipment or tools. The displayed analysis result is provided visually so that the user can intuitively confirm the information, so it is easy to understand the analysis results. Through this, smart city managers can effectively manage rivers, and it is expected that educational institutions will be able to use it as educational material on urban runoff.

Shallow-Water Habitat in a Highly Altered River-Estuary

David Jay[1], William Templeton[1], Amy Borde[2], Heida Diefenderfer[2], Stefan Talke[3]
[1]Portland State University, Portland, United States.
[2]Pacific Northwest National Laboratory, Sequim, United States.
[3]California Polytechnic San Luis Obispo, San Luis Obispo, USA.

This study investigates long-term changes in shallow-water habitat area (SWHA) in the Lower Columbia River Estuary (LCRE), 1928-2004. SWHA in tidal-rivers and estuaries is the area inundated to a depth of 0.1- 2m with velocity <0.3m/s. Juvenile salmonids make extensive use of SWHA for rearing and feeding during their migration, as they adjust to saline conditions. Here we develop a physics-based regression model that evaluates higher high water (HHW) from the ocean to the head-of-tide in the LCRE as a function of river flow, tides, and coastal processes. Using modeled HHW to estimate maximum daily floodplain inundation, we hindcast daily SWHA, 1928-2004. A scenario-based Attribution strategy is used to determine the influence of five Factors on SWHA over the model period: levees, flow regulation, flow diversion, navigational development, subsidence, and climate change. Changes in SWHA due to the Attribution Factors do not sum to the total change, because the factors are evaluated one at a time in isolation, while the total change reflects interactions between factors. The total loss of SWHA has been 55±5% on an annual-average basis, but 63±5% during the spring freshet. Isolation of large parts of the floodplain caused the largest decrease in SWHA 54±14%, while climate change and navigational development are responsible for 5±5% and 4±6%, respectively. The net effect of large changes in the flow cycle due to reservoir management is small, but 15-30% in spring in some parts of the system, depending on assumed subsidence magnitude. The dominant, systematic uncertainty source is poorly-bounded subsidence of the diked wetland surface. Subsidence/infill in the leveed area results in both increases and decreases in SWHA when levees are removed for restoration purposes, depending on the degree and sign of the change. The 2m upper limit on SWHA water depth introduces non-intuitive effects; for example, a very high flow event may not provide extensive SWHA, because most of the floodplain is covered to >2m depth. Also, any factor that reduces mean or peak flows (reservoirs, diversion, and climate change) or reduces average along-channel slope (navigation) becomes more impactful as assumed historical elevations are increased to account for subsidence, while leveeing matters less. The most significant Factor interaction is between hydropower and levees. Levees limit SWHA to the lowest parts of the floodplain; these were historically too deeply inundated to be SWHA during the freshet periods important to salmonids. Because of flow regulation, these areas are now less deeply inundated and are sometimes available as SWHA. Overall, SWHA has moved downward in elevation and closer to the channel, changing the vegetation in areas used by juvenile salmonids. The habitat measured by SWHA is important to many species, and the methodology applied here may be useful in other large river-estuaries.

The Dutch River System: Tipping Points in Supply and Demand

Anna Kosters[1], Bart Maas[1], Nathalie Asselman[1]
[1]Deltares, Delft, The Netherlands.

Worldwide, rivers are used for a wide range of purposes. In the Netherlands, the rivers Rhine and Meuse serve as an inland waterway, a source of freshwater, a route to safely discharge water and sediment and as a partly protected natural area.
The Dutch River system is constantly changing, due to both climate change and human interference. At the same time, the requirements following from the river functions are also changing, again due to climate change, but also due to socio-economic developments. When demands (e.g., sufficient draught for ships) become increasingly heavy while the supply (e.g., available water depth) is decreasing, at some point requirements can no longer be met. This moment is referred to as a tipping point.
We aim to map tipping points for abovementioned functions of the Rhine and Meuse in time, using a combination of modelling, data analysis and expert judgement.
First results show that for many functions, a tipping point has either already occurred or is expected to occur within the next decades, the exact moment depending on the definition of the tipping point and the scenarios and assumptions used.
For inland navigation a tipping point has already been exceeded regarding the navigable depth on the Rhine. According to the Mannheim Act a water depth of at least 2.8 m must be maintained for at least 95% of the time, which is currently not the case. A less strict tipping point definition could be based on the disruption of inland water transport that occurred during a long period of low water depths in 2018 and led to large economic damages in the supply chain. For example, a return period of 10 years or less for such an event would severely decrease the reliability of inland water transport compared to other modalities. Depending on the climate scenario, this can happen as early as 2040.
The north of the Netherlands is heavily dependent on river inflow for its freshwater supply. Freshwater for this region is mainly taken in from Lake Ijssel, a large freshwater lake that is fed by the river Rhine. A tipping point is assumed to occur when the return period of water shortage for this area becomes 20 years or less. Depending on the climate scenario, this can happen between 2035 and 2050.
For nature and flood safety, tipping points are less clearly defined in time. However, also for these functions a conflict between supply and demand is foreseen.
To avoid or postpone tipping points, either the river system must be changed or the requirements placed on it. Considering the time needed to investigate and implement measures, the results of this study can be used to substantiate the urgency to take action.

Trajectories and Future of The Anthropized Seine River

Laurence Lestel[1], Michel Meybeck[1], Catherine Carré[2]
[1]Sorbonne Université CNRS EPHE UMR 7619 METIS, Paris Cedex 05, France.
[2]Univiversité Paris 1 LADYSS, Paris, France.

The Seine River has been profoundly modified by the multiple uses to which it has been devoted (water supply, navigation, energy, pollutant receiver, fishing, swimming). From mid-19th century, the development of river transport induced irreversible modifications of its course. At the same time, the Seine suffered a noticeable degradation of its water quality due to the discharge of wastewater from the City of Paris, to which this river is intimately linked (Lestel et al., 2023). Since the 1950s, housing has become denser in the alluvial plain of the Seine, making the metropolis extremely exposed to the risk of flooding.
In a general manner, the co-evolution of river basin systems and sociosystems remains poorly addressed, particularly over long periods (>100 y). Medium-sized River basins make it possible to perform such detailed analyses, which combines historical river fluxes, material flows, river ecology, environmental history and political ecology. Such an interdisciplinary approach at the scale of the Seine basin, undertaken by the PIREN-Seine research program, started in 1989, has shown how scientific and technological knowledge, environmental awareness, environmental regulations and policies, and political decisions have played a role on water quality during that period (Meybeck et al., 2022).
In this presentation, we will describe some examples of trajectories of the Seine River under the influence of the City of Paris. The controls exerted on the river course and aquatic ecosystem by Paris now far exceed the natural hydromorphological and hydraulic variations in many ways. Many of the existing transformations – channelization, bank artificialization, floodplain sand mining, and damming - might be considered permanent, given the current management policy in the Seine basin, which still gives priority to navigation.
But the Seine is a complex place where this vision can be counterbalanced by that of a river managed according to sustainable principles, whose beauty was magnified by its impressionist painters and recognized by the classification of its banks by UNESCO in 1991.
In conclusion, we will discuss the fact that meeting the new challenges of the 21st century (whether from climate change, or new societal expectations, such as recreational bathing and bank restoration) will require the development of river care, more integrated management, overall plan and better coordination among the different institutions in charge of the river and its functions.

Lestel L., Meybeck M., Carré C., Belliard J. (2023). The Seine, the River dedicated to Paris, In River cultures: life as a dance to the rhythm of the waters, Wantzen K.M. ed., Unesco, 669-693.
Meybeck, M., Bouleau, G., Carré C., Garnier, J., Lestel, L. (2022). Rivers help us to quantify the socio-ecological functioning of their basin at the Anthropocene: The Seine example (1850-2020), Comptes-rendus, Geoscience, doi.org/10.5802/crgeos.140

Mapping Capacity, Demand and Pressures for Hydrological Services in Canada

Camille Ouellet Dallaire[1], Bernhard Lehner[1], Elena Bennett[1]
[1]Memorial University, Corner Brook, Canada.

Introduction: Human settlements in Canada are mostly located at the southern edge of the country, but the watersheds that provide Hydrological Services (HS) often span across large northern areas. In the lights of competing interests for undeveloped lands and climate change, it is imperative to identify critical watersheds for the provision of HS in Canada.

Objectives: Ecosystem services are often conceptualized as three main components, namely capacity, demand and pressure. In river systems, the capacity, the demand and the pressure for a service can be separated by long distances and, yet, be connected by river networks. So, to ensure the long-lasting quality of AES, it is necessary to consider and sustainably manage ecosystems upstream of the demand for these services.

Methods: Using four HS, provision of water for municipalities, agriculture, industries and hydroelectricity, a map of critical watersheds in Canada was created using a hydrological approach. The demand for a service was redistributed on the land considering the runoff contribution. We used a cumulative approach to quantify pressure downstream. We map out the hotspots using a relative index and aimed to identify regions and river types potentially at risk. Identifying these key areas is beneficial for long-term and large-scale sustainable management of water resource.

Results: Our results showed that hydrological services across Canada reach far beyond urban center. We also see that the profiles of impact differ greatly between large and small rivers. Most large rivers tend to have a relatively low impact, as opposed to few small rivers tend to have a very large impacts, while the rest remain pristine.

Conclusion: Mapping hydrological services at large scale represent a challenge because of the hydrological connections across areas of capacity, demand and pressure. Without using seamless and large-scale modelling, we would not be able to have a clear understanding of the distributions of impacts and how hydrological services for communities may be at-risk.

Non-Stationary and Frequency Analysis of Extreme Rainfall in regional Watersheds

Yuting Jin[1], Shuguang Liu[1,2], Zhengzheng Zhou[1], Qi Zhuang[1]
[1]Department of Hydraulic Engineering, Tongji University, Shanghai, China.
[2]Key Laboratory of Yangtze River Water Environment, Ministry of Education, Tongji University, Shanghai, China.

With the climate change and rapid urbanization, people's personal and property safety is seriously threatened by increasingly frequent natural disasters like climate events and extreme weather, fundamentally caused by hydrometeorological non-stationarity on the global scale. Research on the methods of non-stationarity identification and frequency analysis of hydrologic time series helps to form an accurate understanding of the current and future change rules of the hydrological process. The Taihu Lake basin is located in the core of the Yangtze River Delta region in China with rapid urbanization in recent years. Flooding caused by increasing extreme rainfall has become one of the key problems affecting the development of this region. In this paper, hence, using rain-gauge rainfall data from 1961 to 2019 and IMERG satellite rainfall from 2000 to 2020, non-stationary and frequency features of extreme rainfall in the Taihu Lake Basin, China are analyzed. The Mann-Kendall (MK) test and the Pettitt test are used to identify the trend changes and mutations of rainfall series in 8 water conservancy zonings of the Taihu Lake basin. The magnitude, intensity, and duration variability of extreme rainfall are analyzed based on extreme rainfall indicators the number of heavy rainfall days (R10mm), very wet days (R95p), and the maximum 1-day rainfall amount (Rx1d). Using the stochastic storm transposition (SST) method, intensity-duration-frequency curves (IDFs) are obtained for each water conservancy zoning. The results show that the annual total rainfall of 63% water conservancy zoning in the Taihu basin have an overall increasing trend, and 83% rain-gauges have mutations at a significant level of 0.05. These non-stationary changes in rainfall have a close link to regional economic development. For instance, the rainfall series of Baoshan rain-gauges in Puxi zoning (i.e., Shanghai in this zoning is one of a megacity in China) have a significant change point in 1979, which coincides with the rapid development of urbanization in the region. However, the rainfall series of Liyang station in the Huxi district covered a large mountainous area has no significant mutation. The R95p and Rx1d in 38% water conservancy zoning have shown an overall upward trend over the past two decades and a significant upward trend in the past five years. Given non-stationary changes in rainfall, there are significant differences in the results of design storms in the basin. Without considering the rainfall spatiotemporal variabilities will lead to underestimation of IDFs, increasing uncertainty in storm-derived flood estimations. The results of the study provide a reference for understanding the non-stationary variations of extreme rainfall in the Taihu Lake basin, China. It also provides scientific guidance for flood control planning in the basin that shared similar hydrometeorological characteristics under the changing environment.

Protection Systems for Bedload Management in Torrents

Lisa Puschmann[1], Markus Moser[1]
[1]Department of Torrential Processes, Austrian Service for Torrent and Avalanche Control, Tamsweg, Austria.

Bed load management in Austria is achieved with the means of slit dams, beam dams and bedload-sorting dams, with sloping rake constructions as a functional part of the dam. The design of such rakes was optimized based on practical experience first and foremost, with the objective of filtering out undesired woody debris. A rake design with multiple kinks, terminating in a horizontal section, was found to promote the floatation of incoming woody debris, while the slightly inclined lower section of the rake ensured that fine grained particles were able to pass through for a longer window of time during a flooding event. This construction ensures that sediment is already passed through the openings and into the lower reaches of the torrent both during the approaching flood wave as well as during its tail end. In vulnerable lower reaches of a torrent where deposition of fine-grained bedload is unwished for, the size of the openings of the sorting dam is of principle importance. Only rough estimates of the transport capacity of such lower torrent reaches are currently available to be used in dimensioning calculations of these sorting dam openings. Such estimates do not take the effects of woody debris into account, however, nor are hydraulic backwater effects that are due to the reduction of the cross section caused by the beams or the sorting part of the construction. The objective is to optimize the "functional elements" of the bedload managing constructions in regards to hydraulic discharge processes, bedload transport and woody debris. Using the many years of practical experience in the Austrian Service for Torrent and Avalanche Control as a starting point, model simulations and results from field studies should be used as a means to achieve further improvement.

Pressure and Sensitivity Analysis of the 15 Largest River Basins

Ahmet Göktas[2], Muhammet Azlak[1]
[1]General Directorate of Water Management of Turkiye, Ankara, Turkey.
[2]Gazi University, Turkey.

Rivers have an important role in the development of civilization. All human settlements, agricultural areas, and industrial facilities have developed in the areas adjacent to water. As a result of this, many river watersheds are under intense anthropogenic pressures. Moreover, climate change also enhances the issue and creates a multiplier impact. According to UNESCO (2020), it is estimated that the total water consumption of humanity increased approximately 9 times between 1900 and 2010. Furthermore, a projection made for the year 2050 estimates that the population is expected to increase by 55%.

Under increasing pressures such as population, the importance of water-related information has risen. However, the information on the largest water resources on earth consists of various estimates from a global perspective and there is no basin-specific and up-to-date assessment of the current status of the World's Large Rivers. In this regard, all the global estimations might not be realistic and not give a correct insight into the water resources concerned. Therefore, to get a more accurate estimation of the status of water resources, assessments need to consider the status and the dynamics of basins.

In this study, climatic, hydrological, and socio-economic data reflecting the current situation in the basin were compiled by making an inventory scan through the databases of various international institutions and organizations (FAO-AQUASTAT, WRI-Resource Watch, etc.) and a GIS-based database was created. By using the database, up-to-date basin-specific statistical information on significant impacts was obtained. The scope of the database consists of several water-related pressures and characterization data such as land use, population, dams, river network information, urban areas, water use, river fragmentation, and hydrological pressures. In the assessment, studies were carried out by taking into account the impact of the population, sectoral pressures, and the possible impacts of climate change. Sensitivity analysis was conducted on the stress, pressure, and impacts of the sectors on the rivers by using actual data. As a result, within the scope of the analyzes conducted, the impacts arising from agricultural pressures, urban water use, and industrial water consumption in 15 large river basins were determined and the sensitivity of the basins was revealed by using actual data. Although the 15 largest river basins examined in the study are the largest basins in the world in terms of surface area, the characteristics of these basins such as water collection area, flow regimes and flow amount, and the socio-economic structures in the basins differ significantly from each other. Therefore, each basin has its own sensitivity threshold.

A Multi-Objective Multi-Reservoir Study using Particle Swarm Optimization under Hedging

Kanishk Saxena[1], Nagesh Kumar D.[1,2], S.K. Satheesh[1]
[1]Divecha Centre for Climate Change, Indian Institute of Science (IISc) Bangalore, Bengaluru, India.
[2]Department of Civil Engineering, Indian Institute of Science (IISc) Bangalore, Bengaluru, India.

With the increasing occurrence of water shortages worldwide, it is crucial to optimize the operation of multipurpose reservoirs to conserve as much water as possible while ensuring dam safety and effective flood control. The policies for multi-reservoir systems, which specify the releases from each reservoir based on the overall system storage and individual reservoir storage, provide clear guidance on actions to be taken in different system conditions. Recent technological advancements have led to the development of computationally efficient metaheuristic algorithms (MAs) for the integrated optimization of multi-reservoir syste Metaheuristics apply random elements in structure to search and conform to guidelines derived from natural phenomena. Particle Swarm Optimization (PSO) is a metaheuristic method based on the social behavior of bird flocking, used to solve optimization problems and overcome the nonlinearity and nonconvexity of the problem domain. PSO is similar to Genetic Algorithm in fitness and population initialization, but individuals evolve through cooperation and competition, and the search is not reliant on the initial population, overcoming common problems of conventional optimization techniques like local optima.
In extreme events, Hedging is used to ration water supply to meet different demands. During droughts, it is crucial to save some of the available water to prevent future shortages. The standard operating policy may result in severe scarcity in single instances or repeated consecutive short supplies. Hedging involves incurring small losses in the present to prevent more significant losses in the future. When applied to flood control, storage space is a scarce resource that must be allocated wisely between present and future periods. Optimal hedging releases are effective for mitigating medium-sized floods and reducing overall risk. The accuracy of inflow forecasts, available flood storage, risk tolerance, and water use preferences of decision-makers significantly impact the success of flood control operations. Therefore, a comprehensive and adaptive hedging strategy that balances benefits and dam safety is necessary. Currently, the potential of hedging is underutilized, and further research is needed.
The Krishna Basin, the second largest east-flowing river basin in Peninsular India, has witnessed a rapid increase in demand and conflicting demands from multiple stakeholders for various purposes in recent decades. The present study aims to comprehend the multi-reservoir system in the Krishna Basin and determine the various objectives for each reservoir to obtain optimal monthly releases through the application of a new meta-heuristic algorithm and Hedging rule curves, and compare the results with other optimization techniques across the stream. The work will aid in characterizing the evolutionary dynamics of extreme events like droughts and floods, and their spatial and temporal distribution, in a climate change scenario.

Lessons Learned from Evaluating Australia's Famous Proposed Inter-Basin Diversion Scheme

Cuan Petheram[1], Arthur Read[2], Justin Hughes[2], Chris Stokes[3]
[1]CSIRO, Hobart, Australia.
[2]CSIRO, Canberra, Australia.
[3]CSIRO, Townsville, Australia.

Since first proposed 85 years ago, Dr John Bradfield's "nation building" 1500-km inter-basin water diversion scheme proposal has been a millstone around the necks of successive federal and state governments. So engrained is the scheme in the Australian psyche that drought in Australia has become synonymous with calls from high-profile Australians, media personalities and politicians for the schemes construction.

With the last technical evaluation of the Bradfield Scheme in 1982, the Australian Government commissioned Australia's national science agency, CSIRO, to undertake a comprehensive multi-disciplinary analysis of Bradfield's Scheme to objectively assess the numerous claims and counterclaims made by advocates and critics alike.

Rapidly yet objectively evaluating the scheme involved identifying optimal water storage and diversion infrastructure configurations along the potential water supply line, which required the development of novel water infrastructure alignment and optimization tools, such as the Dam Site model for automatic dam site evaluation and the Water Route model for optimal channel alignment and costing, and then linking these tools to a bespoke river system model.

This assessment found that Bradfield's Scheme and its modern variants were technically feasible, and that a series of potential dams and tunnels on the Tully, Herbert and Burdekin rivers in North Queensland could potentially result in the mean annual release of 1880 GL of water (after releasing water to meet the needs of downstream entitlement holders in the Burdekin catchment) into a 1600–km gravity water supply channel to St George on the Condamine-Balonne River, the closest major irrigation area in the 1 million km² Murray–Darling Basin (MDB). After losses it was calculated that a mean of 1270 GL of water could be diverted annually to St George, which is equivalent to 25% of the average annual volume of water used for irrigation in the MDB between 2015 and 2019.

The optimal backbone infrastructure configuration (i.e., dams, pipes, tunnels and channels) to St George was estimated to cost between $15 billion and $30 billion (assuming favorable geological conditions) with an annual cost of between $130 million and $255 million. Although technically feasible the cost of diversion infrastructure added such a large premium to the cost of water that future crop revenues would never pay off the cost of the water storage diversion infrastructure alone.

High financial losses, ecological impacts and community concerns associated with Bradfield-style schemes could potentially be mitigated by strategic development and staging of smaller resource developments situated closer to where the water is captured and to better match where future demands and opportunities are greatest.

Finally, water resource development requires trade-offs. These trade-offs are more contentious with Bradfield-style schemes where water is transferred from one basin to another because the benefits accrued by one community occur at the expense of another.

Sustainable Management of The Navigability of Large Natural Rivers

Erik Mosselman[1], Calvin Creech[2], Jean-Michel Hiver[3], Nils Huber[4]
[1]Deltares & Delft University of Technology, DELFT, Netherlands.
[2]US Corps of Engineers, United States.
[3]Université Libre de Bruxelles, Belgium.
[4]Bundesanstalt für Wasserbau, Germany.

Many rivers in the world have been regulated or trained for protection against floods, water supply, navigation, hydropower generation, agriculture and other societal services. The world's largest rivers, however, have often remained natural or quasi-natural, with unregulated hydrology and unconstrained morphology. The river can freely respond to the environmental boundary conditions provided by the watershed. The significant depths and widths of large natural rivers offer opportunities for navigation. In such rivers, however, it is often not technically feasible nor environmentally desirable to improve navigability through river training works. The only solution is then to assist the river in maintaining a navigable channel through specific actions – for example morphological dredging or adaptive management of the navigation channel itself. It is within this context that PIANC (World Association for Waterborne Transport Infrastructure) has established Working Group 236 to develop guidelines for improving navigability conditions on natural or quasi-natural rivers, while maintaining morphological processes and natural river form and function. Its key objectives include: 1) development of guidelines to improve and maintain the navigability in natural rivers; 2) assess the sustainability of river training works designed to improve the navigability; 3) assess the sustainability of dynamic river management (monitoring and shifting of navigation aids to adapt the navigation channel to the river dynamics); 4) highlight the technical, operational, economic and environmental considerations for navigation in natural rivers compared to that in regulated rivers and canals; and 5) improve the understanding of the physical processes in natural rivers, developed with or without river training works. The guidance includes a planning framework for developing a navigability improvement masterplan for natural or quasi-natural rivers, and the integrated and adaptive management strategies that can be applied at a system scale. Specific interventions and measures have been identified to meet the dual goals of maintaining morphological river function and improving navigability conditions. They include dynamic charting; morphological dredging and disposal management; temporary, adaptable, and flexible training structures (TAFTS); riverbed armoring and sediment nourishment; rock excavation; meander cutoffs; localized traditional river training structures; and channel closure strategies. The guidance also presents the continual monitoring, management, and operational tools available for improving navigability in a morphologically active river. The more fluvially active and dynamic natural and quasi-natural rivers will require new and innovative strategies to monitor the fluvial and geomorphic changes of the system in order to inform managers and navigators. Case studies are presented that include the Madeira River (Brazil); Magdalena River (Colombia); Niger Delta (Nigeria); Yangtze River (China); the Brahmaputra-Jamuna River (India); and the Red River (Vietnam).

Water Sharing Between India and Pakistan: Losses Suffered Because IWT

Jorgen Fredsoe[1]
[1]Professor Emeritus DTU-Construct, Lyngby, Denmark.

Introduction: This study is about the economic consequences for the local community in the former J&K in relation to the water sharing of the waters in the Indus River and its tributaries between India and Pakistan. J&K – or Jammu and Kashmir – were earlier a state in India, but October 31 2019 the status was transformed from being state to be two Union Territories in India: UT Jammu and Kashmir and UT Ladack.
The water sharing agreement is named Indus Water Treaty or IWT, and was signed by Prime Minister Jawaharlal Nehru from India and president Ayyub Khan from Pakistan in 1960. The local population already then felt they were not involved in the content of the Treaty, which was developed nation-wise, and they have since then felt that the Treaty is very costly for the (former) state of J&K. The state therefore decided to ask independent investigators to estimate how much this Treaty affects the economy.

Objective: The purpose of water sharing is to ensure a certain security of water supply from a running river for the downstream nation, when the river crosses a border between two nations.
IWT is analyzed with a view to the meaning of the most important clauses dealing with irrigation and hydropower.

Methods: IWT is not a mathematically water sharing between India and Pakistan. Instead, it has some main restrictions for India as the upper riparian regarding the Western Rivers:
• It limits the future expansion of irrigated cultural land: the main impact is caused by restrictions due to irrigation of additional cultivable land.
• It restricts the live storage capacities of the Hydropower Plants (HEPs) reservoir, so they become in the category of "Run-of-the-River" HEP. The shortcomings of this concept is discussed with respect to power production and flushing capability of the reservoir. Restrictions on water level variations in the reservoir causes limitations in the utilization of all turbines in the pre- and post-monsoon period. This causes drop in Firm Power and a loss in the annual energy production. Because it is not allowed to install a bottom gate in the dams, missing ability to flush the sediment increases the O&M.
Further, the impact of IWT on flooding, climate change, environmental flow and socioeconomics is discussed.

Results and conclusion: Totally, the annual loss for J&K in relation to the Treaty is estimated to be about 40 mills. USD, which is a central estimate for an average year. This estimate will increase to about 100 mills. USD, when the full potential of HEPs in the river system is utilized.

Flood Management Application Example in Large River Basin

Gülşah Cakir Heiḱ al[1], Erkan Eminoğlu[1], Filiz Malkoç[1], Serkan Buhan[2], Yasemin Yılmaz[1], Ali İhsan Akbaş[1], Özden Ertürk Gazel[1], Mehmet Uğur Yıldırım[1]
[1]General Directorate of State Hydraulic Works, Ankara, Turkey.
[2]Scientific and Technological Research Council of Turkey, Ankara, Turkey.

Good management of large river basins during rainy periods is critical. If the peak flows that occur in these basins due to sudden precipitation and snowmelt cannot be controlled and shifted, they may cause great flood risks. For this purpose, it is important to monitor the river basin and to make water inflow forecasts of the reservoirs with high spatial and temporal resolution by considering the whole basin, and to develop systems that operate the basin by taking into account the constraints of the basin according to these forecasts. In this article, studies on the evaluation and management of the entire basin structure are presented in order to eliminate the risk of flooding, especially in the wet season when the amount of empty volume in the dam reservoirs is quite low. It is essential to carry out flood routing by using reservoirs in river tributaries, which have more empty volume and relatively less peak flow, and reduce the maximum value of the peak flow and spread it over time. In order to minimize the flood risk, the reservoir system of the cascaded basin is operated with optimum management approaches and the dam levels are controlled by a common mechanism. In addition, within the scope of this optimum basin management strategy, grid-based hourly resolution forecast of up to 10 days were produced, taking into account each point in the river network. These high-accuracy instantaneous peak current forecasts allow the system to start operating days in advance of taking the necessary precautions. Thus, the maximum level of flood void volume will be created in the basin on the day and hour of the peak flow. The ATHOM system, which was developed for this purpose and has been operational since 2018, has been used to reduce the sudden peak flows in the Seyhan river basin in 2019 and 2020, and to manage the basin in an optimum way by eliminating the flood risks. As a result of the joint communication between the central and regional dam operators, the risk in the river bed was dampened without any dam flood danger, and these dangers were overcome with minimum damage. The successful results obtained for the peak current estimates, operating curves and applied policies created with the ATHOM system are presented. When the goal of extending this system to other large river basins in Turkey is achieved, it will be ensured that all river basins are monitored at the national level, water inflow forecasts are made and operating policies are determined.

Synthetic Series and Optimization: Hydropower Dams of The Grijalva River

Valencia Rosa[1], Ramó Domínguez, Maritza Liliana Arganis Juarez[1], Eduardo Juan[1], Alejandro Mendoza[1], Rosalva Mendoza[1], Eliseo Carrizosa[1], Faustino De Luna[1]
[1]Universidad Nacional Autónoma De México. Instituto De Ingeniería, Ciudad De Mexico, Mexico.

In Mexico, the Balsas and Grijalva rivers are the largest rivers in the country. Reservoirs were commissioned on them to allow a better management for agricultural and public water supply, and also for hydropower generation, mainly during the hours of higher, which is why they become the main hydroelectric plants in Mexico. In this research, the stochastic dynamic programming methodology (SDP) was used as a method of optimizing a function that takes into account the maximum generation of electrical energy, avoiding unwanted events such as deficits and spills, and avoiding leaving or falling below the proposed guide curve. The guide curves are limits of maximum or minimum storage levels proposed throughout the year, which guarantee the demands and safety of the reservoir. To obtain the best optimal operation policy, in this research tests were carried out by changing the guide curve, obtaining the simulation and optimization of the operation of the dams with the inflow of the historical series and the long-term simulation using 10 synthetic series with 1000-year records, created with the modified Svanidze method. The results of the study indicated that the establishment of the guide curves throughout the year in the La Angostura and Malpaso reservoirs makes it possible to guarantee low levels in the reservoirs before the start of the rainy season, so that the extractions and uses in the electricity generation will continue to be guaranteed , so the results of using a combined guide curve (and applying the operation policy called Test 7) pose the best scenario for the variables analyzed (energy, spills, deficits, minimum and maximum initial storage).

We thank the DGAPA, UNAM within the PAPIIT Project IN100422 for the support to carry out this research.

Assessing The Reach-Scale Channel Pattern of Rivers in Albania

Bestar Cekrezi[1], Marta Crivellaro[2], Flamur Bajrami[1], Klodian Brahushaj[3], Klodian Skrame[3], Guido Zolezzi[1,2]
[1]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy.
[2]Center Agriculture Food Environment, University of Trento, Trento, Italy.
[3]Department of Applied Geology Environment and Geoinformatics, Polytechnic University of Tirana, Tirana, Albania.

Introduction: Within the South-Eastern European region, Albanian rivers have been reported as some of the highest sediment transporting streams worldwide, when compared with other rivers in similar climatic - geomorphic settings. The study provides a comprehensive understanding of typical channel patterns in the region and contributes to addressing the limited hydro-morphological data in South-Eastern European rivers.

Objectives: We aim to assess the morphological patterns of major rivers in Albania Vjosa, Devoll, Shkumbin, Erzen, and Mat, by examining their main stems and largest tributaries. We develop a regional-level quantitative picture of the most typical channel patterns and explore possible dominant catchment-scale controls. We quantify the channel morphologies of these rivers at the reach scale, providing valuable insights into their physical characteristics. Through this work, we contribute to the improvement of river basin management strategies and advance possible understanding of river morphological dynamics in the region.

Methods: We adopt the IDRAIM (Rinaldi et al., 2014) framework for the segmentation of the river network into hydro-morphologically homogeneous reaches, and extract reach-averaged values of the channel slope, active corridor width, reach length, together with indicators of lateral confinement and of the main geological layers in which every reach is found. To support our analysis, we utilize semi-automated remote sensing data, including digital terrain models 10x10 m, and orthophotos with a resolution up to 20 cm.

Results: Results offer a regional-level quantitative picture of the most typical channel patterns and allows to explore possible dominant catchment-scale controls. We compare our findings with previous studies at similar scales focused on the European Alps (Hohensinner et al., 2020).

Conclusion: The outputs of the work contribute to addressing a well-known management challenge typical for South-Eastern European rivers, represented by the fragmented availability of hydro-morphological data. Their collection and systematic organization into usable databases are often limited by several obstacles of different nature, despite the crucial relevance of such data as baseline information for the development of river basin management plans.

The 5-country UNESCO Biosphere Reserve Mura-Drava-Danube

Arno Mohl[1], Kerstin Böck[1]
[1]WWF Austria, Vienna, Austria.

For a long time, large parts of the river landscapes along the former Iron Curtain between the Baltic Sea and the Black Sea in Europe remained largely unaffected by serious encroachments. With the end of communism at the end of the 1980s and since the eastward enlargement of the EU, these forgotten river paradises were catapulted into another age. Suddenly, they have become areas of human economic interest. On the one hand, this pressure has threatened to irreversibly destroy the last intact river areas. On the other hand, new opportunities for cooperation in nature conservation, river management and sustainable development have emerged. Current examples can be found on the lower reaches of the Drava and Mura Rivers and in the adjacent floodplains of the middle Danube River between Austria, Slovenia, Croatia, Hungary and Serbia.

For about 30 years, conservationists have now been working on the preservation of this largest near-natural river and floodplain landscape in Central Europe to create a transboundary protected area, the so-called Amazon of Europe. In September 2021, the area was recognized by the UNESCO as the world's first 5-country biosphere reserve (TBR MDD). With an area of around 930,000 hectares, it is Europe's largest coherent river protection zone.

The biosphere reserve significantly counteracts the loss of biodiversity in Europe through its size and protective measures. The increased resilience of the rivers as a result of strong protection and large-scale transboundary river restoration will help to mitigate the negative effects of climate change within the region. The harmonization of human activities with the goals of the reserve will lead to sustainable practices and green job opportunities. Above all, the transboundary, protected area is a peace project, which strengthens the political stabilization process in the region, through joint approaches and cooperation.

The lessons learned gained from the long-term conservation efforts can be taken up to be applied in the protection and restoration of other transboundary riverine areas in Europe and on global level.

The Upper Neretva – How Europe`S Pristine Rivers Are Dam(N)Ed

Sarah Höfler[1], Thomas Friedrich[2], Kurt Pinter[2], Wolfram Graf[2], Steven Weiss[3]
[1]blattfisch e.U. - Consultants in aquatic ecology and engineering, Wels, Austria.
[2]University of Natural Resources and Life Sciences (BOKU), Vienna, Austria.
[3]University Graz - Faculty of Natural Sciences, Graz, Austria.

The upper reaches of the Neretva River, located in Bosnia and Republica Srpska, is a stunning riverine ecosystem, leaving even experienced scientists speechless. At this point the Neretva - as encountered multiple times all over the Balkans - numerous dams are planned for the generation of hydroelectric power. With the largest dam project, Ulog, already being implemented, almost no preliminary considerations with regard to impacts on bedload regime, morphology and aquatic ecology nor environmental impact assessments have been sufficiently implemented. European laws, which should also be applied in candidate countries such as Bosnia, and international requirements for the protection of fauna and flora remain largely ignored.
In an attempt to prevent further exploitation, morphological and ecological data were collected during the Science Week Neretva in summer 2022. These initial data from an electrofishing campaign, native benthic fauna surveys, bedload inventory and habitat characteristics mapping will be presented. Of special interest are many strictly protected native aquatic species, for example softmouth trout (Salmo obtusirostris), white clawed crayfish (Austropotamobius pallipes) or marble trout (Salmo marmoratus), for some of which the Neretva populations are of global importance to conserve the species as such.
In addition to these nature conservation aspects, it is the consequences on hydrology and sediment balance that will have a major impact on the local population and local economy, such as fisheries, recreational use, and tourism.
The scientific effort is meeting dam construction practically in real time. While it may come too late to prevent all projects, it forms the knowledge base to save the pristine rivers in Europe`s blue heart.

The Shkumbin River, Albania: Hydromorphological Evolution Phases

Flamur Bajrami[2], Marta Crivellaro[1], Bestar Cekrezi[2], Klodian Skrame[3], Guido Zolezzi[1,2]
[1]Center Agriculture Food Environment, University of Trento, Trento, Italy.
[2]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy.
[3]Department of Applied Geology Environment and Geoinformatics, Polytechnic University of Tirana, Tirana, Albania.

Introduction: The Shkumbin river in Albania is historically recognized for its relevant sediment transport rates and higher sediment yield (around 3000 ton/km2yr, Pano, 1992) compared to wider catchments in the region and to rivers in similar climatological and environmental settings worldwide. However, little is known about its recent morphological dynamics and trajectories of evolution.

Objectives: In this work, we analyze the recent evolution and controlling factors of the Shkumbin hydromorphology, coupling the reconstruction of channel adjustments over the past 60 years with the analysis of possible drivers of change at the catchment and reach scales, including trends in its flow regime and human pressures on the system (sediment mining, longitudinal fragmentation mainly through water abstractions). Coupled with such analysis, we then investigate to which extent the observed channel adjustments may have affected the sediment transport rates of the Shkumbin, with a focus on its lower reaches.

Methods: The study integrates remote sensing, topographic surveys, statistical analysis and sediment transport rates estimation by means of classical formulae that are applied using reach-averaged parameters (Van Rijn, 1984).

Results: Our results reveal two major phases in the recent morphological trajectory of the Shkumbin river. In the first phase (1960-1990), active channel narrowing (43%) appears to be controlled by climatic oscillations and the variation of the hydrological regime at the catchment scale. The second phase (1990-nowadays) presents a diverse response of the system to intense sediment mining, concentrated in its middle-lower reaches, with doubled narrowing rates in the most impacted reaches (45% narrowing against 20% narrowing in the less impacted reaches) and visible signs of riverbed incision.

Conclusion: Our findings on the morphological trajectories are relevant for river management, particularly regarding the effect of sediment mining in altering the inherent morphological behavior of the Shkumbin river. Moreover, the work provides a reference knowledge for integrated river and coastal management, by assessing the likely variability of the river sediment load to the coast associated with the observed channel adjustments. The integration of such a baseline knowledge can support the future water and sediment management in the area, primarily through the development of river basin management plans.

Pano N., 1992. - Dinamica del litorale albanese (sintesi delle conoscenze). - Proceedings of the 10th A.1.0.L. Meeting, G. Lang Publishers, Genova, Italy: 3-18.
Van Rijn, L.C., 1984. Sediment transport, part II: suspended load transport. J. Hydraulic Division 110(11), 1613—1641.

The Global Biodiversity Framework's Restoration Target and South-Eastern Europe's Rivers

Theresa Schiller[1], Michele Thieme[2]
[1]WWF Germany, Berlin, Germany.
[2]WWF US, Washington DC, USA.

Loss of fluvial or river connectivity is considered one of the main threats to freshwater ecosystem integrity and has been linked with the extinction and population declines of freshwater species. Restoring rivers means restoring the unimpeded movement of species and the flow of natural processes that sustain life on earth. Until recently, no global river restoration target existed. The new post-2020 Global Biodiversity Framework (GBF), now includes Target 2, which declares to “Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal marine ecosystems are under effective restoration…”. Yet, Target 2 risks to not deliver on the result, as it is expressed in percentage of degradation, while a definition of degradation has not been agreed within the CBD process, due to the lack of consensus on the baseline. Moreover, measuring restoration of rivers in percentages of areal extent (e.g., hectares) leads to the omission of a crucial habitat for a high number of species.
We therefore suggest the adoption of a global river restoration target based on linear units. Rivers are linear systems through which water flows in varying quantities such that their restoration is best measured either in linear units or river flow volume. While the latter are still being developed, linear units are most appropriate for measuring how connectivity, and therefore restoration of riverine ecosystems, can be monitored and properly reported in the GBF.
In this study we used the available Connectivity Status Index (CSI) to measure river connectivity and indicate where restoration may be needed. The CSI’s component indicators are tied to the four connectivity dimensions; the indicators are river fragmentation, flow regulation, sediment trapping, water consumption, and infrastructure development in riparian and floodplain areas. A global application of the CSI has calculated index scores for over 12 million river kilometers. To arrive at a target number for global river restoration, we calculated 30% of the total river kilometers of impacted river reaches (CSI < 95%).
Using this methodology, the global target for restoration of transformed to natural river reaches is at least 300,000 kilometers. Here we provide a recommended global river restoration target based on CSI data from the global assessment.
The results of the global river connectivity assessment could be used to support countries in Southeast Europe to set river connectivity restoration targets at national, basin- or region-level. Compared to percentage-based targets, km-based targets might better translate to national restoration targets which can be achieved practically. Moreover, to secure that the restoration investments have long lasting benefits on river connectivity and to protect still existing free-flowing rivers in Southeast Europe – the Blue Heart of Europe – it will be crucial to establish effective river protection mechanisms.

Joint Fact Finding for River Restoration with REACT and D-Ecoimpact

Valesca Harezlak[1], Marc Weeber[1], Mijke Van Oorschot[1]
[1]Deltares, Delft, Nederland.

River restoration is a complex process partly due to the demanding interdisciplinary cooperation between experts, policy makers and stakeholders. The involved parties each have their own understanding of and interests in the management and ecological functioning of a riverine system. Additionally, the required data and knowledge for this ecological system understanding is often scattered, anecdotal and/or hard to access. Yet, a shared understanding based on sound data and knowledge is a prerequisite for successful river restoration.
Nowadays, both global data and knowledge are more widely and readily available than ever. However, local data and system knowledge are not, and may prove crucial for in depth understanding of the ecological functioning of a riverine system. Joint fact finding of the stakeholders involved in river restoration projects is helped by providing global data and knowledge and including locally available additions. This allows, through ecological response analyses, for a joint understanding of the ecosystem under consideration, including its ecological bottlenecks. From this understanding, strategies and scenarios may be developed for successful river restoration.
To bring all stakeholders along in the understanding of the ecological functioning of a riverine system, tools that bring together the relevant data, knowledge and assess the ecological significance can be helpful. Important aspects of those tools are their access to data sources, flexibility in data input and fast rendering of output that is easy to interpret. Over the past 2 years we have developed the tools REACT and D-EcoImpact and their combination adheres to those requirements. REACT is an overarching framework that assembles publicly available global data, like earth observation and global precipitation, temperature and elevation maps for a river of interest. Through REACT this data is connected to WFlow, an open-source hydrological model, that is used simulate the discharge and stream velocity. These data and model results are translated to indictors of the river’s dynamic and characteristics. REACT provides generic habitat and trait knowledge rules (e.g., dose-effect relations, classifications) as a mean for an initial approximation of a spatial ecological arrangement of river features (e.g. spawning habitat).
D-EcoImpact calculates the spatial ecological arrangement based on the relevant indicators and knowledge rules. This tool handles a myriad of different data input formats and types, like model output, maps and measurement data, and combines it into a coherent dataset. The baseline calculation of D-EcoImpact reflects the current ecosystem situation. This provides an ecosystem visualisation, supportive to a first level of shared understanding on the ecological processes. Continuing from there it can be used to determine the effects of strategies and scenarios on the river’s ecological functioning through refinement of the input data and knowledge rules.
This combination of tools, knowledge and stakeholder involvement allows for widely supported river restoration.

Defining Environmental Flows for Ramganga with Habitat Simulation Model Mesohabsim

Piotr Parasiewicz[1,2], Stefan Schmutz[3], Michael McClain[4], Jyoti Nale[5], J. Anthony Johnson[6], Amiya K. Sahoo[7], Rebecca Tharme[8], Ashvani Gosain[9], Luc Verelst[10]
[1]Rushing Rivers Institute - Poland, Minsk Maz., Poland.
[2]National Inland Fisheries Institute, Olsztyn, Poland.
[3]University of Natural Resources and Life Sciences, BOKU, Vienna, Austria.
[4]IHE Delft Institute for Water Education, Delft, the Netherlands.
[5]India-EU Water Partnership Action, GIZ India, New Delhi, India.
[6]Wildlife Institute of India, India.
[7]ICAR-Central Inland Fisheries Research Institute, India.
[8]8Riverfutures, Peak District National Park, UK.
[9]Indian Institute of Technology Delhi, New Delhi, India.
[10]Spatial Systems, Belgium.

We introduce an approach for river basin wide determination of environmental flows using the habitat simulation model, MesoHABSIM. The approach follows tenets of the natural flow paradigm and recommends dynamic flow regime adjustments that support the needs of aquatic fauna over a range of bioperiods. We present the demonstration results of the technique on a test sites in Ramganga River Basin in India and a concept developed for environmental flows determination across the river basin. It included delineation of watershed into fish community macro habitat types and developing MesoHABSIM model for the expected community. This served as a foundation for water allocation scenarios and adjustments to promote efficient use of water resources. The scenarios are also effective under the future climate change hydrology. The method has been included in the 2020 Guidance Document for Environmental Flows Assessment and Implementation in India developed under the India-EU Water Partnership (IEWP) Action. The environmental flows assessment through this method and further implementation should allow for more efficient use of water, including for agriculture, while protecting the natural heritage of India. Implementation requires capacity development and the establishment of a database of relationships between environmental flows and fish habitat availability, derived from strategically selected river reaches.
This research is financially supported by the India-EU Water Partnership (IEWP) Action. IEWP is implemented by GIZ India through a co-financing by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ) in conjunction with the BMZ supported Indo-German Development Cooperation Project Support to Ganga Rejuvenation.

Impacts of Harmful Algae on Macroinvertebrates in The Oder River

Andrzej Kapusta[1], Arkadiusz Duda[1], Maja Prusińska[1], Sylwia Jarmołowicz[1], Agnieszka Napiórkowska-Krzebietke[1], Jakub Pyka[1], Konrad Stawecki[1], Grzegorz Wiszniewski[1]
[1]National Inland Fisheries Research Institute, Olsztyn, Poland.

Introduction: Water quality impairments that lead to harmful algal blooms damage declining native species. Prymnesium parvum is a brackish water golden alga that can survive in salinities less than 1 ppm and when it blooms it can create toxins that kill aquatic life. We report a case study of a macroinvertebrates life kill associated with P. parvum in the Oder River, Poland's second largest river. Water quality and a golden algae bloom appeared to play a significant part in the freshwater macroinvertebrates life kill.

Objectives: Less attention has been paid to the impact of P. parvum on macroinvertebrate communities. Our research aims to determine the response of a wide range of freshwater macroinvertebrates to toxins after golden algal blooms.

Methods: Benthic macroinvertebrate assemblages, water chemical variables and environmental degradation in the middle and lower Oder River were studied. Seven sites in the Oder River were studied from September 2022. Macroinvertebrate species composition was studied at each site and the relationship between living and dead individuals was established. Based on the data collected after the ecological disaster in the Oder River and observations from other river systems, an analysis of the restoration potential of the macroinvertebrates was carried out. Combined chemical and biological data were used to explore a generic model for predicting recovery rates and success.

Results: High mollusc mortality was recorded in the middle and lower reaches of the Oder River, with shells of Dreissena polymorpha mainly found attached to the substrate, shells of small bivalves and snails buried in the sand in samples taken in the middle reaches. In the lower river, shells of large bivalves of the genera Unio and Anodonta were found. These were bivalve shells carried downstream.

Conclusion: Although fish losses often get the most attention when these toxic events occur, entire aquatic ecosystems are threatened by golden alga. P. parvum has been characterized as an ecosystem disruptive species because of its ability to cause recurrent fish kills and affect various taxa and trophic levels within a water body. Even when chemical water quality has been improved substantially, the ecological status of macroinvertebrate communities may not reflect the reduced pollution levels achieved until sufficient time has elapsed to allow re-colonization (perhaps decades).

The Odra River – an Inventory After a Fish Kill

Jacek Szlakowski[1], Wojciech Prekurat[1], Paweł Buras[1], Janusz Ligięza[1]
[1]Inland Fisheries Institute, Department of River Fisheries, Piaseczno, Poland.

In the river fish monitoring for the Water Framework Directive in the Odra River, between 2011 and 2022, 25,553 fish of 38 species, including six non-indigenous species, were sampled. For the total sample of 279,003 fish, it makes 9.2%. The share of five most common protected and listed in the annexes of the directive on the conservation of natural habitats and of wild fauna and flora species such as bitterling Rhodeus amarus, spined loach Cobitis taenia, whitefin gudgeon Romanogobio belingi, barbel Barbus barbus, and asp Leuciscus aspius was 4.6%. This alone proves the importance of the Odra River as a significant habitat for fish and an ecological corridor.
In August 2022, a massive fish kill occurred on the Odra River. The accepted course of events could be like that: low water level, high water temperature, discharges of wastewater containing nutrients, especially nitrogen and phosphorus, and discharges of saline mine waters, have triggered the development of an unexpected agent, Prymnesium parvum, known from fish kills in different parts of the world. Initial die-offs of fish and molluscs and significant deterioration of environmental conditions (chemical and microbiological pollution) caused a snowball effect. Deoxygenated water flowed down the river, causing further deaths of fish and molluscs.
It is estimated that at least 223 metric tons of dead fish were utilized along the river course in August 2022. However, it was not possible to collect all the dead fish from the river. At least 24 fish species have been strongly impacted by the fish kill in the lower Odra River, as revealed by the 4508 dead fish length measurements. It has been observed that the share of small-body-sized fish species may be significantly underestimated.
The results obtained in 2022 after the fish kill for the relevant 14 sites were compared with the previous results of river fish monitoring 2014–2021. The main differences concerned the size of catches: the average weight of the catch at the sampling site (6.3 kg×1000 m-2 to 3.7 kg×1000 m-2 in 2022) and the average number of fish caught at the sampling site (337×1000 m-2 to 176×1000 m-2 in 2022). It is impossible to accurately estimate the loss of different fish species population sizes in the 2022 fish kill. However, indirect estimates indicate losses of 50-60%.
P. parvum is a persistent, invasive species. It can cause recurrent deadly blooms. To avoid further harmful algal blooms, one should leave the Odra River seminatural, free-flowing part intact, improve water quality, and significantly improve the organization of water resources management.

Hyperspectral Flights on The Oder River During an Ecological Disaster

Katarzyna Suska[1], Janusz Ligięza[1], Wojciech Prekurat[1], Dominik Kopeć[2], Jan Niedzielko[2]
[1]National Inland Fisheries Research Institute, Olsztyn, Poland, [2]MGGP Aero, Tarnów, Poland.

Introduction: Remote sensing data obtained from satellite, airplane, or UAV altitude makes it possible to gain knowledge about the range and spatial variability of the studied phenomenon in the river. Compared to a UAV, the advantage of using an aircraft is the ability to acquire extensive data in a short period of time, and, compared to a satellite, a higher-resolution image. Hyperspectral imaging is a powerful tool that can be used to manage rivers by obtaining detailed information on water chemistry.

Objectives: Investigation of the spatial distribution of water quality parameters in selected sections of the river during the massive fishkill using airborne hyperspectral imagery. Study the possibility to identify conditions favorable to the occurrence of Prymnesium parvum.

Methods: The study was conducted on 3 selected sections of the Oder River (approximately 150km length). Data collection was carried out using hyperspectral, thermal, and RGB sensors on board the aircraft. Concurrently, water samples were taken for laboratory analysis from 90 locations along the flight path. Water was tested for physicochemical parameters supporting the occurrence and formation of Prymnesium parvum blooms. The data was used for images spectrum calibrations.

Results: Digital maps of the spatial distribution of selected water parameters in the three studied river sections were created. Those correlating with Prymnesium parvum presence were: pH, specific electrical conductivity, sodium, total phosphorus, and nitrogen.

Conclusions: Remote sensing data acquired from the aerial altitude enables an almost " immediate" capture of the extent and spatial variability of the phenomenon under study. Combined with reference data, it is possible to create detailed models of various substances. This allows to assess the impact of nutrients on the quality of fish and mollusk habitat and calculate the probability of Prymnesium parvum habitat. This creates a basis for targeting activities aimed at restoring the Oder River ecosystem and reducing the threats in the future.

Minerals as Provenance Indicator of Sediments Transport by Diyala River

Fouad Al-kaabi[1], Manal Al-Ubaidi[1], Esraa Muhammad Ali[1]
[1]Iraq Geological Survey, Baghdad, Iraq.

Quaternary sediments in the center of Iraq are weathered from igneous-metamorphic complex in the north and northeast of Iraq, northwest of Iran and southeast of Turkey. Different types of minerals and rock fragments from this complex are transporting by rivers in these areas downstream.
A number of sediment samples were taken from Diyala river in Diyala and Baghdad governorates along the lower part of Diyala river sediments in the center of Iraq. The main focus in these samples was the change in mineralogical composition across this river in the studied area. Thus, this study focuses on identification the light and heavy mineral assemblages and their spatial distributions, maturity, provenance in the collected samples.
Examination of the heavy mineral content shows that most samples are dominated by opaque minerals (40.57% – 61.12%). In addition to this group, various percentages of heavy minerals such as pyroxenes, tremolite-actinolite, mica and garnet, with a few amounts of zircon, tourmaline and rutile were presented in the studied samples.
The light minerals composed of quartz, feldspar, and rock fragments which derived from sedimentary, igneous, and metamorphic rock fragments.
The large amount of unstable heavy minerals compared to ultra-stable minerals was referred to immature sediments, arid- semiarid climate, and mechanical weathering in the source area. These immature sediments found to be contained quartz and feldspar together, comparing with mature sediments, that were recognized in south of the study area, were involved only quartz. Studying heavy minerals can suggest that Diyala River sediments was weathered from igneous- rocks from Iran with minor input from metamorphic rocks. Therefore, this study demonstrates that using light minerals in addition to heavy is great benefit in provenance studies.

Hydrodynamic Modeling of Oil Spill in Coastal Areas: Azemmour Estuary

Nisrine Iouzzi[1], Mehdi Haffane[1], Mohamed Chagdali[1], Mouldi Ben Meftah[1], Michele Mossa[1]
[1]Faculty of Sciences Ben M'sik, University Hassan Ii Casablanca, Casablanca 20450, Casablanca, Maroc.

Accidental marine pollution by oil spills can cause severe immediate and long-term damage to marine ecosystems and socio-economic sectors, requiring a fast and efficient detection and monitoring system. The present work focuses on the numerical modeling of the drift and spread of oil slicks under the action of marine current circulation and meteorological weather conditions. This study presents a type of detection method that can predict the spread of the oil spill, its trajectories, and the coastal areas most likely to be affected. The target area subject of study is the mouth of the Azemmour river, located on Morocco’s Atlantic Coast. Given its geographical position at the intersection of the World's Shipping Lines of oil transport, this area, like many other sites in Morocco, according to the environmental sensitivity index (ESI), has been classified as a high-risk area of oil spill accident. A detailed numerical simulation, using the TELEMAC two-dimensional hydrodynamic software, of the behavior and movement of the oil slicks in the aforementioned coastal area was carried out.
By introducing the oil spill point at the mouth of the Azemmour river, the simulated results made it possible to understand the evolution of the spread and trajectory of the oil slick, the travel time of the slick oil from one position to another, the effect of wind on the spreading process and the coastal areas that will be particularly affected. This study is a very relevant management and prevention tool for the effective governance of the Azemmour river estuary area.

Fish Migratory Behaviour in Proximity to the Iron Gate Dams

Marija Smederevac-Lalić[1], Gorčin Cvijanović[1], Mirjana Lenhardt[1,2], Dušan Nikolić[1], Miroslav Nikčević[1], Stefan Hont[3], Marian Paraschiv[3], Marian Iani[3], Rachel Paterson[4], Eva Thorstad[4], Finn Økland[4]
[1]University of Belgrade, Institute for Multidisciplinary Research, Kneza Viseslava 1, 11000 Belgrade, Serbia.
[2]Institute for Biological Research University of Belgrade, Bulevar Despota Stefana 142, 11000 Belgrade, Serbia.
[3]Danube Delta National Institute for Research and Development, 165 Babadag Street, 820112 Tulcea, Romania.
[4]Norwegian Institute for Nature Research (NINA), PO Box 5685, Torgarden, NO-7485, Trondheim, Norway, Trondheim, Norway.

River infrastructures, such as hydropower plants Iron Gate I (IG; rkm 943) and II (rkm 863) represent major obstructions to fish migration in the Danube River. Knowledge about fish behavior and movements in the vicinity of major river structures is required to build effective fish passages to protect migratory fish species, with acoustic telemetry being a useful method for observing such behavior. From autumn 2019 to the spring 2021, the movement of 185 fish (barbel Barbus barbus, nase Chondrostoma nasus, vimba bream Vimba vimba, asp Leuciscus aspius, Pontic shad Alosa immaculata, and carp Cyprinus carpio) were monitored in the Danube River upstream and downstream of the IG II dam using acoustic telemetry. The movements of tagged fish were recorded by a combination of automatic tracking of fish passing receivers deployed in the river and manual tracking by boat. Of the 101 fish released downstream of IG II, 48% moved upstream from their release site and were detected close to IG II. The remaining 84 tagged fish were released in the reservoir between IG I and II, with 49% of fish moving further upstream in the reservoir and 18% reaching IG I, while 48% of the tagged fish moved in a downstream direction and were recorded below IG II. No fish released downstream of IG II were detected in the reservoir between two dams, which indicates that the ship locks on either side of the river do not represent viable routes for upstream migration around IG II. There was also no clear pattern in which side of the river tagged fish preferred to move along. To conserve migratory fish species, dam management strategies that take into account the behavior of fish around such structures is necessary. Acoustic telemetry can be used to inform and guide towards construction of the safe fish passage or adapt structures to improve the movement and fish migration.

Flood Wave Propagation along Euphrates River Due to Haditha Dambreak

Ali Fakhri[1], Lubna Imad[2]
[1]Iraqi Ministry of Water Resources, Center of Studies and Engineering Design, Baghdad, Iraq.
[2]Iraqi Ministry of Water Resources, Baghdad, Iraq.

The Euphrates River is one of the largest rivers in southwest Asia. Its length reaches 2786 km and feeds an area of more than 400000 km^2, which is occupied by about 30 million people. The catchment area of the Euphrates basin is shared by 5 countries (Turkey 28%, Syria 22%, Iraq 47%, Jordan 0.03%, and Saudi Arabia 2.97%), and passes through three countries (Turkey, Syria, and Iraq). Dam failure and the resulting floods from the dam break are hazardous events that highly impact the inundated areas and are less predictable. The simulation of the dam breach failure and the flood wave propagation is necessary for assessing flood hazards to reduce the loss of life. This paper aims to simulate a flood wave in the current status of the Euphrates that results from the probability of a dam break of Haditha dam, located along the Euphrates River in Al-Anbar governorate, Iraq. The expected flood waves are extending downstream of the Dam until Falluja City. The HEC RAS model has utilized Shallow Water or Diffusion Wave Equations of unsteady flow with the Finite Volume Method (FVM), these equations are based on momentum and conservation of mass equation. The importance of studying the probability of dam failure is to reduce the dangers and the damages that may occur in the life and structures along the main cities downstream of the dam. The geometry of the model is prepared depending on the Digital Elevation Model (DEM) covering the study area of the Euphrates River from Haditha Dam to Falluja City. The length of this reach is about 250 km. The study area was divided into about 600000 elements. Stage hydrographs and arrival times in relevant locations are produced to describe the flood wave. Furthermore, an inundation map of the flood is produced using the model results. The results offer a way to predict flood extent and showed that the impact of a predicted dam break of Haditha Dam will be serious, therefore, suitable management is needed to overcome this risk. Moreover, the maps produced by this study are useful for developing plans for sustainable flood management.

The Effect of Mosul Dam Break along the Tigris River

Hanan Al-Timemy[1], Hasan Khattawi[1], Ali Fakhri[1]
[1]Iraqi Ministry of Water Resources, Center of Studies and Engineering Design, Baghdad, Iraq.

The Tigris River is the second-largest river in Western Asia. The catchment area of this river is shared by four countries (Turkey, Iraq, Iran, and Syria). The river also feeds with water from precipitation that falls in the Highlands of Armenian. Along its path, the Tigris River is fed by numerous tributaries that flow from the Zagros Mountains in Turkey, Iraq, and Iran. In Iraq, the river passes through the main cities, especially in Baghdad, the capital of Iraq which more than 8 million inhabitants. This research is carried out to simulate and analyze the seepage, stability, and flood wave for the dam break of Mosul Dam, which was constructed on the Tigris River in the north of Iraq, the model simulates the dam using SLOPE/W and SEEP/W which represented sub-products of GEOSLPOE software based on finite elements, and the HEC RAS software Simulate the flood wave and the inundation area in case of dam break for more than 520 km along Tigris River. In this Research, the water seepage was determined, and the phreatic line and the pore water pressure were modeled for varied levels, maximum (338 m.a.s.l), minimum (300 m.a.s.l). The material properties and the geometry of the dam represented the input data which implement in GEOSLPOE software, and the HEC RAS model geometry was simulated with Digital Elevation Model (DEM), and the flood wave input with a flow hydrograph. The flow net in the body of the dam is applied with code SEEP/W model showing the phreatic line, equipotential line, streamline, and velocity vectors. In addition, the exit gradient and seepage discharge were determined. Also, the analysis of slope stability in the Mosul dam is of high importance, and the identity of the inundation maps is important to minimize the danger of loss of life downstream of the dam due to dam failure. The factor of safety is computed in Spencer Method, and the same method is used to check the stability of the downstream slope of the dam. Theoretical seepage and analysis appeared that a problem may occur in the downstream face of the dam leading to seepage failure when the water reservoir reached the flood level. In this study, some of the solutions modeled using the GEOSLPOE software were suggested to solve this problem, and the danger area downstream of the dam is specified, and the arrival time of the flood wave of the dam failure to the main cities downstream of the Dam is identified.

Derivating Toxicity Indicators for Heavy Metal Vulnerability in Aquatic Organisms

Jinhee Park[1], Sang Don Kim[1]
[1]Gwangju Institute of Science and Technology (GIST), Gwangju, South Korea.

Heavy metals are traditional toxic materials that naturally and artificially occur in the environment. In particular, in water, heavy metals cause strong toxicity to aquatic organisms even at low concentrations. In order to predict the impact of heavy metals and cope with damage, it is necessary to pay attention to species that are vulnerable to the heavy metals in that ecosystem. The vulnerability is a function of exposure, sensitivity, and recovery indices, which are aggregated by biological, ecological, and toxicological information for each organism to heavy metals. This study aims to investigate the heavy metal toxicity index, an additional vulnerability indicator, by expanding the existing vulnerability framework. A total of six heavy metals, including arsenic, cadmium, copper, lead, nickel, and zinc, are investigated in Korean freshwater organisms. The toxicity indicators are derived from toxicity data, including the median lethal concentration (LC50) and median effective concentration (EC50) collected from the USEPA ECOTOX database. Some organisms are not available to find the toxicity data at the organism level, so alternative toxicity data is adopted at the taxonomic level to match at the higher taxonomic levels such as genus, family, and order levels. The collected data is standardized to the toxicity index ranging from 0 to 1 through the min-max method. As a result, most toxicity indices are organized from family level to class level for heavy metals. Overall, there are significant differences in toxicity indices, but the Tukey posthoc test suggests homogeneity between some taxonomic groups. In addition, significant differences were found depending on heavy metals. Aquatic insects have shown to be less vulnerable to heavy metals than other groups, but it is thought that further research is needed because less toxic data is reflected compared to their number of organisms. Currently, the ecological vulnerability assessment is drawing attention, but it is still in the development stage. Given their toxicity indicators and various biological and ecological information, studying the vulnerability will be continuously improving to help identify important organisms to toxic chemicals in the real world.

Improvement of Automated Hydrological Observation Technology and Application

Sheng-Hsueh Yang[1], Wen-Shang Chou[2], I-YU Wu, Jia-Lin Ma[2], Yi-Ping Wu[2], Chia-Wen Lee[2], Keh-Chia Yeh[1], Cheng-Wei Lee[3]
[1]Disaster Prevention and Water Environment Research Center, National Yang Ming Chiao Tung University, Hsinchu, Taiwan.
[2]Water Resources Agency, Taipei, Taiwan.
[3]WaveGis Technology, Taipei, Taiwan.

Hydrological observation techniques, such as water level, river discharge, suspending sediment concentration, bed material load flux observations, rarely integrate observation data at the same period. Especially during floods, environmental constraints such as personnel safety, river water levels are even more difficult. In the past, most of them were estimated indirectly, such as discharge-suspended sediment load rating curve. The bed material load flux is mostly estimated by the proportion of suspending sediment concentration. Watershed management also needs to integrate and provide comprehensive hydrological data after a major flood for analysis of river stability and assessment of embankment safety. This study tries to use different hydrological monitoring instruments to directly measure the observation data of the river site, display the on-site monitoring data, and provide the input conditions for 2D hydraulic and sediment model through the data platform. The research area is located at the Changyun Bridge in Zhuoshui River in central Taiwan. This section of the river is a braided channel with three streams passing through the bridge. In this river section, there are three water level stations, three radar wave surface velocity monitoring stations, two remote CCTV monitoring equipment, one suspended sediment load station and one high-frequency seismic wave instrumentation monitors bed material load flux. The flow discharge with time can be estimated by combining the different water level and flow velocity measurement with the water flow cross-sectional area. One of the objectives of this research is to use a suspending sediment concentration meter to measure the suspended sediment load in each time period, especially the suspended sediment load at medium and high-water levels. The bed material load flux measure uses a high-frequency seismic wave instrument to record the rolling and beating of bedrock particles, and analyzes the riverbed transport flux through frequency spectrum. Set up two CCTV cameras on the bridge to record the fluctuation and displacement of the river surface at 30 frames per second, and then use automatic image capture and the LSPIV technology to estimate the surface velocity and then record the distribution of the river surface velocity when the water level is high. During the research process, data such as flow discharge measurement by the ADCP instrument and the artificial suspending sediment concentration sampling were compared with automated measurement results to evaluate the accuracy of each measurement result. Finally, through the collection data and web-page design, the presentation of automated hydrological observation technology is demonstrated. Also, through the observation data and numerical model to simulate the flood period, analyze and apply the safety and stability of the embankment foundation of the target embankment to achieve the overall safety of the watershed management purposes.

Lena Delta Climate-Driven Changes of Sediment Transport and Channel Dynamics

Sergey Chalov[1,2], Kristina Prokopieva[1]
[1]Lomonosov Moscow State University, Moscow, Russian Federation.
[2]Kazimir Velikiy Bydgoszcz University, Bydgoszcz, Poland.

Lena River delta is the biggest delta in the Arctic Region. Current climate changes influence not only on water regime also changes sediment transport in the delta branches. ERA5-Land reanalysis data along with the long-term monitoring data at Tiksi and Kyusyur weather stations were used to estimate Lena Delta air temperature, precipitation and solar radiation evolution. A significant change in these variables have occurred at the beginning of the XXI century, which could aggravate thermal erosion in the delta mainly composed of permafrost deposits. Significant changes in air temperature were found since 2004, as the trend for the period from 2004 to 2021increase by +1.89°C/10 years. Further long-term variability of suspended sediment changes over the delta was captured for the period from 1989 to 2022 using Landsat satellite data, seasonal variability was explored using Sentinel images from 2016 to 2022. Remote sensing reflectance calibrated with the onsite field measurements of SSC in the Lena River delta expedition on August, 2022. We identify significant variability in the sedimentation processes between left and right sectors of the delta, which is explained by particularities branches networks and geomorphology and the existence of specific drivers — continuous permafrost thaw. Additionally, areas of suspended sediment concentration increase were compared with maps of bottom sediments and GIS study of channel planform changes. The compiled channel changes map explains possible impact of accelerated hydroclimatic evolution on thermal erosion during 2000 to 2021. Finally, the study presents calculated volumes of material exposed to the river due to planform changes and possible impact of thermal erosion and thermal denudation of permafrost banks.

New Insights in The Coupled Danube – Black Sea System

Jürg Bloesch, Bernd Cyffka, Thomas Hein, Cristina Sandu, Nike Sommerwerk[1]
[1]Museum Für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany.

The five Co-Authors act as Editors of an ELSEVIER-Book entitled “Danube River and Western Black Sea Coast: Complex Transboundary Management” in the series “Ecohydrology from catchment to coast”. The book encompasses 18 chapters grouped into three parts and shall be published towards the end of 2023. All chapters are written by well-known experts in their disciplines and cover a wide range of disciplines and sectors.
The first part presents the social and eco-hydrological aspects of the Danube River Basin and the adjacent Black Sea coast. The emphasis is on the natural and human historical development of the region, the hydrological system, the cultural and biological diversity, the importance of biodiversity for human society and the strong interlinkage between the Danube River and its recipient, the Black Sea.
The second part highlights key pressures and challenges of implementing transboundary water management in the most international Danube River Basin and the Black Sea coastal system. It focuses on hydromorphological alterations and overexploitation of natural resources, invasive alien species, climate change impacts, the role of protected areas in maintaining biodiversity, the role of international commissions and relevant stakeholder participation for transnational management.
The third part presents the visions for a sustainable future in the Danube – Black Sea region. It especially summarizes how to achieve an ecological balance and meet the requirements of EU environmental legislation, the role of ecosystem services, ecological corridors, wetlands and floodplains for nature conservancy and ways to enhance rehabilitation and habitat restoration to ensure biodiversity recovery.
A closing chapter highlights the current gaps in knowledge and implementation, the socio-ecological perspective, possible ways of improving the knowledge transfer towards society and key decision makers for achieving sustainability in the region and the societal consequences of choosing alternative development paths.
The key messages are that social and ecological systems are intrinsically linked and that nature is our main ally in the fight against the massive global challenges we are already facing. Biodiversity change triggers the decline and safety of human society and a paradigm shift from economy primacy to true sustainability is urgently needed to secure the future of the Danube and the adjacent Black Sea region.