

Preface

This book is the result of a collaborative effort between the Institute of Geophysics (IGF) of the Polish Academy of Sciences with its Center for Polar Studies KNOW and the European Initial Training Network Project HYTECH. The papers presented at the 34th International School of Hydraulics held at Żelechów Palace in Poland during May 11–14, 2015 constitute the basis for this volume. International School of Hydraulics is a biannual event run under the auspices of the International Association of Hydro Environment Engineering and Research IAHR and the Committee of Water Resources of the Polish Academy of Sciences. This year the School was devoted to hydrodynamic and mass transport at freshwater aquatic interfaces, but papers related to other problems from the broadly understood hydraulics were also accepted. Although not published in this volume we need to mention three invited lectures presented by renowned specialists in the field: Prof. Heidi Nepf from Massachusetts Institute of Technology, USA, talked about vegetation hydrodynamics at both the blade-scale and canopy-scale, Prof. Bernhard Statzner, former director of National Science Research Center (CNRS), France, talked about testing predictions of changes in the abundance and community structure of benthic invertebrates and fish after flow restoration in a large river (French Rhône), and Prof. Peter A. Davies from University of Dundee, UK, discussed the complex problem of waviness on density interfaces in stratified water bodies. The presence and advice of these eminent scientists created a fantastic scientific atmosphere during the meeting.

The International School of Hydraulics in its current form organized by the Institute of Geophysics was first held in 2006 and was initially conceived as a forum to bring together leaders in the field of broadly understood hydraulics and young scientists. The diversity of participants in this event allows for cross-fertilization between basic and experimental scientists as well as senior and more junior investigators. The School permits reflection on the current state of the field, unanswered but critical questions, and potential future directions for research.

This Conference Proceedings volume contains the written versions of most of the contributions presented during the School which took place at the Palace

Żelechów, situated in a historical building located some 90 km from Warsaw. The conference has been an excellent opportunity for participants coming from numerous countries from all over the world to present and discuss topics in their respective research areas.

Physical, biochemical, and ecological processes in natural water bodies have been the subject of intense research by different scientific disciplines in the past few decades. Environmental studies of natural water bodies are a relatively new area of research, spanning over no more than fifty years. As regards combined training in environmental sciences and engineering, the first undergraduate and graduate academic programs started in the US only in the 1980s. The dawning of environmental studies in the late twentieth century has seen developments often confined to individual classical areas of expertise, e.g., hydraulic engineering, water chemistry, and population ecology with only a few pioneering programs promoting interaction among specialities (e.g., the International Biological Program in the early 1960s). The development of a truly interdisciplinary approach to environmental studies, so as to address the modern concerns posed by climate change, appears one of the main challenges of the new century. In 2000, the European Commission made the sustainable use of water resources a priority (Water Framework Directive, WFD), setting a timetable for the achievement of adequate ecological standards. This timetable has been driving the work of environmental scientists and practitioners as well as environmental agencies and authorities throughout Europe over more than a decade. A call for the protection and sustainable use of water resources also came from the ICCP (Intergovernmental Panel on Climate Change, rep. 2007).

Natural water streams are characterized by heterogeneities in terms of transported matter, physical properties, biological species, and ecotones. Interfaces are the contact locations between two or more substances or phases, e.g., water and sediment. An inherent property of interfaces in natural water bodies is that they are sites of high gradients of quantities (e.g., fluid velocity, concentration, and temperature). This property induces significant, site-specific diffusive momentum, and mass fluxes at these physical interfaces. Understanding of transport mechanism is an essential step toward assessing the vulnerability of the natural environment to anthropogenic stresses. Typical stream interfaces at a micro scale are inorganic, microbial, and vegetated structures such as sediment grains, biofilms, and periphyton. At an intermediate (meso-) scale, comparable to the water depth, interfacial heterogeneities include sediment clusters, individual submerged and emergent plants, and shallow hyporheic zones. At larger scales heterogeneities include bedforms, bars, vegetation patches, and deep hyporheic zones. As the scale of consideration increases from micro- to meso- to macro-scale the analysis progressively changes from fundamental solutions applicable to well-defined conditions toward combined models where mutual interactions between transported matter and interfaces must be accounted for by adopting appropriate theoretical frameworks, statistical tools, and probabilistic methods.

The HYTECH—‘Hydrodynamic Transport in Ecologically Critical Heterogeneous Interfaces’—project is an Initial Training Network funded within the Marie Skłodowska-Curie Actions in the 7th Framework Programme of the

European Commission. The project started in 2013 and will end in 2016. The HYTECH project provides training to doctoral and postdoctoral fellows to encourage innovation in the solution of environmental problems involving the transport of inorganic and organic matter, including solutes, colloids and sediments in river flows, and across the boundary interfaces. The HYTECH fellows originate from all continents, counting 8 fellows from Europe (Italy, Greece, Portugal, Latvia), 3 fellows from Asia (Iran), 2 fellows from Africa (Sudan), 1 fellow from America (Argentina), and 1 fellow from Oceania (New Zealand). Fellow supervision and network progress is assisted by the Expert Advisory Board comprising four eminent scholars: Profs. Peter Davies, Heidi Nepf, Gary Parker, and Bernhard Statzner. A number of institutions are involved in realizing the HYTECH project and they are listed below.

The *University of Padova (Italy)* is coordinating the HYTECH project and hosts one doctoral and one postdoctoral fellow. The two projects focus on modeling mass transport in wetlands looking at developing optimal design criteria and on the role of cohesive sediments in determining erosional resistance of bed deposits.

Gerstgraser Ingenieurbüro Für Renaturierung (gIR) is a German private company specialist in renaturalization projects. It contributes to HYTECH hosting a postdoctoral position devoted to the analysis of the implementation of the Water Framework Directive and the Flood Directive in different EU member states.

The *University of Aberdeen (UK)* participates in HYTECH hosting two doctoral fellows. They are developing innovative instrumentation for field observation of the hydrodynamics of vegetated streams and working on the development of new Double Averaging theoretical derivations of mass transport equations.

The *Centre National de La Recherche Scientifique (CNRS, France)* contributes to HYTECH through the Laboratory of Ecology LEHNA. They host a doctoral fellow conducting field research on the growth and feedback hydrodynamic processes of vegetated species in a French river.

The *Koninklijk Nederlands Instituut Voor Zeeonderzoek (NIOZ, NL)* participates in the project hosting one doctoral fellow focusing on geometrical patterns of aquatic vegetation and ecological engineering of aquatic landscapes.

GHT Photonics is an Italian private company specialized in hi-tech instrumentation for field survey and environmental monitoring. It hosts two postdoctoral fellows with the aim of developing a new instrument for river bed survey and new fiber-optics applications in fluid mechanics.

The *Technische Universitaet Braunschweig (D)* offers access to its large laboratory facilities to HYTECH fellows and hosts two doctoral fellows who concentrate on environmental-friendly engineering solutions to river restoration and on resistance models for vegetated channels.

The *Politecnico di Milano (Italy)* is involved in HYTECH through one doctoral position looking at Lagrangian observation of sediment particle dynamics.

The *University of Sheffield (UK)* hosts two doctoral fellows looking at experimental innovation for the observation of bedload and suspended sediment transport.

Water & Environmental technology (WET Engineering, Italy) is a private company specialized in hydropower and river tracer techniques. It hosts one doctoral fellow developing tracer tests methods and relevant modeling tools.

A series of institutions and private companies also support HYTECH as Associated Partners: *Queen Mary University of London*, *Leibniz Institute of Freshwater Ecology and Inland Fishery (Berlin)*, *Centre for Ecology and Hydrology (Edinburgh)*, *Norwegian University of Science and Technology*, *Umbria Region*, *SGI-Studio Galli (Padova)*, *SELC (Venezia)*.

It has been a great pleasure to edit the proceedings. We have considerably enjoyed working in cooperation with the International Scientific Committee to call for papers, review papers, and finalize papers to be included in the proceedings. Refereeing papers for an international conference such as International School of Hydraulics is a complex process that relies on the goodwill of those researchers involved in the field. A list of reviewers of papers is given below.

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Hydrodynamic and Mass Transport at Freshwater
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34th International School of Hydraulics

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