Innovative means to harness water energy in the DBS System

Harnessing energy from water and other renewable sources in a way that does not significantly affect ecosystems is a major issue for the DBS system. Innovative engineering schemes are needed for sustainble energy generation, from the river water flow to the marine waves and currents.

Promoting Cross Border Environmental Stewardship in the DBS System through Citizen Science

Systematic and timely monitoring of large river-sea systems with complex geopolitical histories remains challenging. A number of emerging technologies, including smart-phones and inexpensive sensors which can be widely distributed now provide the framework for effective monitoring of water quality.

Detailed plans and concepts for a new regional research infrastructure in the field of integrated river – delta – sea management in the Danube – Black Sea area are in preparation.

This is an opportune time to address the challenges, identified above, by a cross-disciplinary distributed Research Infrastructure (RI) on freshwater – marine systems. The RI can build upon the world- leading capabilities of the European environmental science community to deliver a step-change in our understanding.

The initiative to develop RI in DBS is further enhanced by the coincidence of:

- – Political framework including EUSDR and ESFRI.
- – Timeliness of technical advances
- – Resource exploitation
- – European e-infrastructures initiatives (Geant & PRACE)
- – Existence of the GEOSS and the COPERNICUS programmes

It is important to look forward and consider the degree to which the research needs can be addressed by the two new EUSDR flagship research initiatives in the Danube – Black Sea system (River, Delta and Sea). Together these initiatives (DREAM and DANUBIUS-RI) have the potential to provide world-leading facilities that will facilitate inter-disciplinary research and enhanced implementation within the Danube – Black Sea system.

The Human Capital Development Programme

DANCERS proposes a model for a new Danube educational programme that could lead to a better integration of the river-delta-sea management practices. In principle, the new Danube education programme has at its core a pyramid base and approach that aims to address different levels of education. The main aim of such a programme would be to build a network of institutions and develop agreements and mechanisms to facilitate knowledge exchange within the Danube Basin.

The major outcomes of the project will be published in a special issue of the scientific jounral Science of the Total Environment. FP7 DANCERS was funded under the EC Grant no. 603805. The in extenso results of the project were published in the following books, freely available also online (see below):

References

Stanica A., Bradley C., Tyler A., Habersack H. (edc.) (2015): Towards the Integrated Management of the Danube River – Danube Delta – Black Sea system: collaboration of the two EUSDR Flagship Distributed Research Infrastructures. ISBN 978-606-94058-4-0 (print), 978-606-94058-5-7 (online). Bucharest, 2015

Habersack H., Tyler A., Bradley C., Stanica A., Popescu I. editors. 2015. Towards the Integrated Management of the Danube River – Danube Delta – Black Sea system: Proposal for the development of the Human Capital. ISBN 978-606-94058-6-4 (print) 978-606-94058-7-1 (online). Bucharest, 2015

Gault J., Bradley C., Tyler A., Stanica A., Papathanassiou V., Gettel G. editors. 2015. Towards the Integrated Management of the Danube River – Danube Delta – Black Sea system: Proposal for a Strategic Research and Innovation Agenda. ISBN 978-606-94058-2-6 (print) 978-606-94058-3-3 (online). Bucharest, 2015

JDS 3 from an environmental history and social science perspective – Part II: What the river told us about its socio-natural history

Gertrud Haidvogl: *Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences Vienna, Austria, e-mail: gertrud.haidvogl@boku.ac.at*
Martin Schmid: *Institute of Social Ecology, Alpen-Adria-Universität Klagenfurt-Wien-Graz, Austria, e-mail: martin.schmid@aau.at*

Introduction

Following a first review of the third Joint Danube Survey (JDS 3) from an environmental history and social sciences point of view (Schmid and Haidvogl 2015), this second and final part discusses selected main results of this basin-wide survey (ICPDR 2015a). Our overall aim is to enrich and broaden the scholarly debate about the current state of the Danube by including long term, socio-ecological perspectives from environmental history. We concentrate on three topics that are also relevant for determining the ‘ecological status’ of a distinct river section as well as of the Danube river basin (DRB) as a whole according to the EU-Water Framework Directive (WFD):

hydromorphology, fish diversity, and pollution. We suggest interpreting pertinent results from JDS as a body of information not only on the current but also on past socio-natural states of the DRB. We argue that environmental history can help to address the dynamics of the social, cultural, and economic sphere that have caused the current state of the river – the very same state natural sciences observe and assess in important monitoring schemes such as JDS.

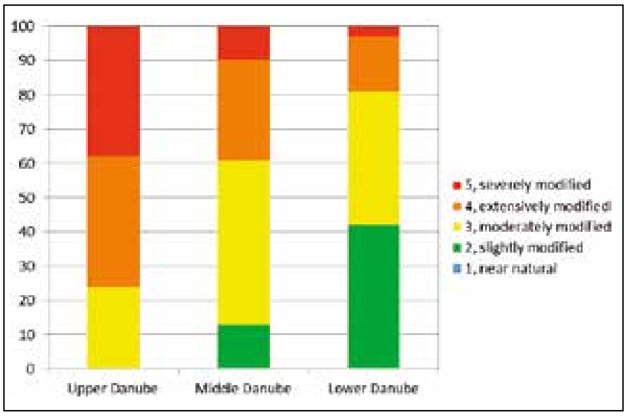

Figure 1. The hydromorphological situation of the upper, middle and lower Danube according to JDS 3 (Source: ICPDR 2015a)

The hydromorphological status of the Danube

During JDS 3, hydromorphology and longitudinal connectivity of the Danube were investigated and evaluated based on the type and intensity of human alterations. The assessment used the 5-tiered scheme of the WFD. Following the approach of a “natural reference state”, no section of the Danube was ascribed a ‘near-natural’ state. From an environmental history perspective this is not at all surprising, no one familiar with the region’s history would expect river stretches without visible traces of (past) human uses in industrialized regions like the DRB. Along the upper Danube, more than 75 % of sites were classified as ‘extensively’ or ‘severely modified’ due to channelization, flood protection, hydropower dams and altered sediment transport. Hydro-morphological conditions are less modified in the lower Danube and in the delta, where more than 40 % were classified ‘slightly altered’ while only less than 20 % as ‘severely’ or ‘extensively modified’. The middle section is in-between *(see Fig. 1).*

Scrutinizing these findings from a long-term perspective, one has to discuss the role of river section-specific environmental features together with the political and socio-economic history of the riparian Danube countries. In other words: How did navigation, land use, urbanization and flood

Figure 2. The Danube in Vienna around 1837. Schweikchardt v. Sickingen, Perspektiv-Karte des Erzherzogthums Oesterreich unter der Ens

protection as well as hydropower evolve with environmental features along different Danube sections? In-depth socio-ecological studies of the entire Danube are still lacking, but the existing literature allows compiling some indications.

Environmental features of the upper Danube differ significantly from the middle and lower sections. Slope and subsequently velocity are important conditions for a river's navigability. The Danube's gradient drops from up to 1,4 ‰ in German sections to less than 0,1 ‰ in Hungary and even less than 0,04 ‰ in the lower Danube. In general, steeper slopes imply higher riverine dynamics. Thus, regulation works were more urgent in the upper Danube. After the 1830s, steam ships started to operate on the Danube. The larger these ships got, the higher was the water depth they needed. The adverse effects of unstable discharge and especially low-flow conditions on navigation increased. At the same time, new fossil energy sources enabled large-scale river regulation measures. In the 19th century, river channelization projects were subsequently not restricted to the upper Danube. In the middle and lower river sections, particularly the Iron Gates, a series of partly narrow gorges with high velocity, large water depths and dangerous boulders, was a focal point (Gatejel 2016). Larger engineering measures were also undertaken up- and downstream of Budapest and in the delta's Sulina channel. But until the middle of the 20th century, these measures were mainly limited to the construction of a middle or low-flow bed and did not cause a decoupling of floodplain water bodies at higher discharges (Schmid 2013; Lóczy 2007).

What made a difference between the upper, middle and lower Danube in practice was the different pace, scale and intensity of flood protection and, in the 20th century, the development of hydropower. Until the 19th century, land demand along the river was more intensive in Austria or Germany, were urban settlements and agriculture extended directly up to the river banks (see e.g. Haidvogl 2008). This required rather early flood protection measures especially in urban areas such as Vienna *(see Fig. 2)* already in the late 19th century (Winiwarter et al. 2013; Nenciu Posner and Armaş 2014). In contrast, along the middle and lower Danube, flood protection projects and floodplain drainage measures were often implemented only after World War II. For instance, in the 1960s, 5500 km^2 or 72 % of the Romanian floodplains were drained and transformed into arable land, commercial forest plantations and fish farms. In the Danube delta, c. 1000 km^2 were enclosed with polders for agriculture, forestry and aquaculture between 1960 and 1989 (Sommerwerk et al. 2009).

A major difference stems also from the role of hydropower in the different Danube sections. First plans to build hydropower dams in the present Slovakian and Hungarian section date back to the 1910s and thus to the same period when first hydropower projects for the Austrian Danube were developed (Jansky et al. 2004). However, especially in Hungary, 'political and economic turmoil, border and population shifts, and changing usage rights in the period during and between the two world wars hindered the further development and implementation of regulation projects in the middle Danube' (Jansky et al. 2004). Only in the 1960s, old plans for hydropower use downstream of Bratislava and in the Iron Gate *(see Fig. 3)* were revisited and implemented.

Fish diversity of the Danube and the concept of native and alien species

In accordance with the requirements of the WFD, fish serve as an indicator of human pressures in freshwater systems. Appropriate assessment methods have to identify the deviation of the present species composition, abundance and biomass from an assumed natural status without human influence. Based on sound fish ecological samplings, JDS 3 proved a high abundance of non-native and eurytopic species. Altogether, during JDS 3, 25 neophytes, 34 non-native macroinvertebrates and 12 non-native fish species have been found (ICPDR 2015a). In relative terms, the upper river section is more effected by species classified as non-native than the lower Danube, in particular in case of fish, because of the human-induced expansion of ponto-caspic species toward the middle and upper Danube. This indicates the effects of habitat destruction and a successful competition of non-native species against those perceived as native.

From a practical point of view, the use of native species diversity makes inasmuch sense as ecological assessments need some kind of reference point. However, from a historical perspective, such an approach poses several conceptual and methodological questions (Haidvogl et al. 2014). First, fish communities have been and are changing constantly due to shifts of environmental factors. The most prominent example is the ('natural') recolonization especially of warm water preferring fish species after the end of the last ice age, approximately 12,000 BP. Also during the last centuries the distribution and abundance of fish changed with climate,

Figure 3. The island Ada Kaleh around 1900. It was flooded after the opening of the Iron Gate dams. Library of Congress, Prints & Photographs Division, Photochrom Collection

e.g. when average temperatures decreased from a medieval climate optimum to the little ice age from the 13th and 14th centuries onwards – independently from human influences (see e.g. Luterbacher et al. 2016 for a recent long-term study of average summer temperatures; Pont et al. 2015). The effects of temperature shifts overlapped with those from millennia-long human alterations, which is one of the difficulties one encounters when reconstructing 'natural' fish communities. In addition, the differentiation between native and non-native species as main feature of biological assessments can be sometimes more complex than expected. Of course, for most of the Danube's fish species written historical sources and archaeological remains together with biogeographical knowledge support the determination of the native distribution at least when assuming more or less stable climatic conditions. However, there are also species for which this identification is difficult due to lack of information. An example for the Danube is the western tubenose goby *Proterorhinus semilunaris,* for which the distribution before the late 19th century is unclear especially for the middle Danube. Inconsistencies in the identification of the native range are the consequence (see Schotzko & Wiesner 2009, Wiesner et al. 2008). A similar case is Giebel *Carassius gibelio* for which reports of the 18th century for the lower Danube are unclear. As for various species of the Neogobiidae family Giebel seems to have spread towards the middle and upper Danube in and after the 1970s.

A long-term perspective can shed light on another aspect of the present ecological assessment of rivers and their biota. As explained in part I (Schmid and Haidvogl 2015), environmental objectives and concerns depend on specific interests of different societal groups in the river; these interests and thus the mode of perception depend on the socio-economic and cultural context and are thus highly variable over time. For instance, in the 19th century the main aim of experts managing fish populations was to improve fish productivity to supply humans with local and regional fish. Often, alien fish species promised better productivity, also because of an – at least assumed – better adaptation to environmental conditions in rivers which had been systematically altered for navigation, hydropower use or floodplain colonization. Since the late 1970s, a general sensitivity toward environmental change and pollution and in particular the recognition of the large-scale modification of rivers and their biota initiated a focus on conservation and restoration in river management. In accordance with the 'paradigm of an equilibrium' (cp. Schmid and Haidvogl 2015), ecologists and biologists nowadays favor a certain group of species (the so called 'native') while they are concerned against others (the non-native and/or invasive). Such action is not always based on detailed evidence about the effects non-native species (might) have on the native ones, thus such interactions need further studies as emphasized by ICPDR (2015b).

Pollution as a long-term problem: The legacies of polluted soils

During JDS water quality was investigated in terms of organic matter and nutrients input as well as in terms of hazardous substances released especially by industrial activities and agriculture.

Diffuse input of nutrients, herbicides and pesticides from the agricultural sector, which was rapidly industrialized after World War II all over the DRB (although with regional differences), is currently a main reason of water pollution and difficult to control and manage. Another source of water pollution is the industrial sector including mining activities. The communist era was characterized by planned economies stuck to classical heavy industries and in general to inefficient use of resources (Harper & Turnock 2002). Only little effort was put into sewage collection from industries and communes and their treatment. In addition, for the middle and lower Danube catchment the aftermath and long-term environmental costs of the Balkan Wars deserve more attention (e.g. UNEP – OCHA 2000). Environmental legacies of soil contamination in a more distant past are not yet addressed sufficiently in scientific studies. But two examples stemming from the more recent past can highlight the risk from such pollution sources.

On the evening of January, 30th, 2000, a tailings pond burst at a facility near the city of Baia Mare, Romania, which was reprocessing old mining tailings and re-depositing the waste sludge into a new tailings pond (Harper 2005). This led to approximately 100 000 m^3 of wastewater containing up to 120 tons of cyanide and heavy metals, which were released into the Lapus River, the Somes and Tisza rivers in Hungary before entering the Danube. On March 10th, 2000, another tailings dam burst in Baia Borsa in the same region close to the Ukrainian border. While some of this material was retained within the dam complex, 20 000 tons of sediments were released into the Novat River, a tributary of the Viseu and Tisza rivers. Baia Mare is a region of particularly intensive industrial development and this led to several incidents. Macklin et al. (2003) have studied the environmental legacies in the area and found an unexpected high rate of heavy metals in the sediment showing that the concentrations of heavy metals are long-standing. Spills are dangerous but the environmental problems in the area have not arisen in recent years. They have a much longer history as Macklin et al. (2003) conclude: "… more widespread contamination is clearly arising from ongoing mining activity in the Cavnic, upper Lapus, Sasar and Tisla catchments. While not downplaying the short term ecological effects of the spills, they should be seen more as compounding much longer term problems associated with many decades of poorly regulated, and largely untreated, industrial, mining and urban discharges into local rivers." (Macklin et al. 2003, p 256; see also Winiwarter 2013).

Pančevo, a small town in Serbia situated approximately 20 km northeast of Belgrade has a large industrial complex with petrochemical industry and a nitrogen fertilizer company. It has become infamous for 250 tons of liquid ammonia spilled into the Danube during the Balkan wars. This was not a direct consequence of military attacks but a preventive measure. A direct air strike on stored ammonia could have killed large numbers of people. "This release was probably responsible for fish kills reported in the Danube, up to 30 km downstream" (UNEP 1999).

While details about the two events described above are known, a heritage of a considerable number of former mining and industrial sites in the Danube catchment and in its floodplains remains largely unknown and difficult to reconstruct, e.g. because the sites have been closed decades ago and no detailed records are available (UNEP-Balkan Task Force 2009). Acknowledging the legacies of past economic activities and the subsequent environmental risk, river managers have started to compile major accident risk spots and the calculation of Water Risk Indices (ICPDR 2015b).

Conclusions

In this part of our review of JDS 3 we have used results of the survey to show how an interdisciplinary oriented, long-term perspective – as offered by environmental history – contributes to a more comprehensive interpretation of results of ecological assessments. The present hydromorphological state of different sections of the Danube or the level of water pollution reflect the history of the various regions and the changing patterns of how riparian human societies interacted with the river. Also, present biodiversity has a history as it is composed of recent and long-term fluctuations of the natural environment and to an even greater extent by human uses of the river and its floodplains. History can help to raise awareness of the consequences of our basic conceptions of nature, as in the case of 'native' and 'non-native' fish. This is not to blame the concepts of conservationists or to argue that they are obsolete. It rather shall initiate a reflection upon the time-dependence of the ways we perceive, use and modify rivers like Danube.

References

Gatejel L (2016): Overcoming the Iron Gates: Austrian Transport and River Regulation on the Lower Danube, 1830s-1840s. Central European History, 49, 162–180.

Haidvogl G (2008): Von der Flusslandschaft zum Fließgewässer. Die Entwicklung ausgewählter österreichischer Flüsse im 19. und 20. Jahrhundert mit besonderer Berücksichtigung der Kolonisierung des Überflutungsraums. PhD Thesis, University of Vienna.

Haidvogl G, Lajus D, Pont D, Schmid M, Jungwirth M, Lajus J (2014): Typology of historical sources and the reconstruction of long-term historical changes of riverine fish: a case study of the Austrian Danube and northern Russian rivers. Ecology of Freshwater Fish, 23, 498–515.

Harper K (2005): "Wild Capitalism" and "Ecocolonialism": A tale of Two Rivers. American Anthropologist 107, 221–233.

Harper F, Turnock D (2002): Environmental problems in East-Central Europe. 2nd ed. Routledge, London and New York.

ICPDR – International Commission for the Protection of the Danube River (2015a): Joint Danube Survey. A comprehensive analysis of Water Quality. ICPDR – International Commission for the Protection of the Danube River, Vienna.

ICPDR – International Commission for the Protection of the Danube River (2015b): The Danube River Basin District Management Plan. Part A – Basin-wide Overview. Update 2015. ICPDR – International Commission for the Protection of the Danube River, Vienna.

Jansky L, Murakami M, Pachova NI (2004): The Danube: Environmental monitoring of an international river. United Nations University Press, Tokyo, New York, Paris.

Lóczy D (2007): The Danube: Morphology, Evolution, and Environmental Issues. In: Gupta A (ed.): Large Rivers: Geomorphology and Management. Chichester, John Wiley and Sons: 235-260.

Luterbacher J, Werner JP, Smerdon JE et al. (2016: European summer temperatures since Roman times. Environmental Research Letters 11, 024001. http://dx.doi.org/10.1088/1748-9326/11/2/024001

Macklin MG, Brewer PA, Balteanu D, Coulthard TJ, Driga B, Howard AJ, Zaharia S (2003): The long term fate and environmental significance of contaminant metals released by the January and March 2000 mining tailings dam failures in Maramureş County, upper Tisa Basin, Romania. Applied Geochemistry, 18, 241–257.

Nenciu Posner C, Armaş I (2014): Historical perspective on structural methods for flood protection in Lower Danube. Georeview 25,1. http://dx.doi.org/10.4316/GEOREVIEW.2015.25.1.171

Pont D, Logez M, Carrel G, Rogers C, Haidvogl G (2015): Historical change in fish species distribution: shifting reference conditions and global warming effects. Aquatic Sciences, 77, 441–453.

Schmid M (2013): Towards an Environmental History of the Danube/Zu einer Umweltgeschichte der Donau Understanding a great European river through its transformation as a socio-natural site, c.1500–2000. Habilitation, Alpen-Adria-Universität Klagenfurt-Graz-Wien.

Schmid M, Haidvogl G (2015): JDS 3 from an environmental history and social perspective – Part I: Danube research across disciplines and the selection of environmental problems. Danube News 32, 6–10.

Schotzko N, Wiesner Ch (2009): Fischökologie. In: Institut für Wassergüte (Ed.), Das Leben im Donaustrom. Joint Danube Servey 2 (JDS 2) Zweite gemeinsame Donaumessfahrt der Internationalen Kommission zum Schutz der Donau (IKSD) im Jahre 2007. Schriftenreihe des Bundesamts für Wasserwirtschaft 32, 148–189.

Sommerwerk N, Baumgartner C, Blösch J, Hein t, Ostojic A, Paunovic M, Schneider-Jakoby M, Siber R, Tockner K (2009): The Danube River Basin. In: Tockner K, Uehlinger U, Robinson CT (eds.): Rivers of Europe. Amsterdam u.a., Elsevier: 59–112.

UNEP-Balkan Task Force (1999): The Kosovo conflict. Consequences for the environment and human settlements. United Nations Environment Programme and the United Nations Centre for Human Settlements (Habitat), Nairobi. http://postconflict.unep.ch/publications/finalreport.pdf

UNEP (2009): Mining and environment in the Western Balkans. United Nations Environment Programme Vienna, Vienna. http://www.unep.org/pdf/MiningBalkans_screen.pdf

UNEP – OCHA (2000): United Nations Environment Programme UNEP – Office for the Co-ordination of Humanitarian Affairs OCHA, Cyanide Spill at Baia Mare Romania - UNEP/OCHA Assessment Mission. Spill of Liquid and suspended Waste at the Aurul S.A. Retreatment Plant in Baia Mare, Geneva.

Wiesner Ch, Schotzko N, Cerny J, Guti G, Davideanu G, Jepsen N (2008): JDS-2 Fish. In: ICPDR – International Commission for the Protection of the Danube River (eds). Results of the Joint Danube Survey 2. ICPDR – International Commission for the Protection of the Danube River, Vienna.

Winiwarter V (2013): The 2013 DIAnet International School, its aims and principles against the background of the sustainability challenges of the Danube River Basin. In: Brumat S, Frausin D (eds.): DIAnet International School Proceedings 2013 "Interdisciplinary Methods for the Sustainable Development of the Danube Region. 19–41.

Winiwarter V, Schmid M, Dressel G (2013): Looking at half a millennium of co-existence: The Danube in Vienna as a socio-natural site. Water History 5, 101–119.