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Editorial

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Dear Readers,

Hydromorphological change and sediment management have been identified by ICPDR as significant water management issues of the Danube. Two projects presented in Danube News 37 focus on these topics. The contribution of Peter Fischer from the Aueninstitut Neuburg/Donau describes a recent investigation of the bypass system "Ottheinrichbach", which makes a lateral connection between the Danube and its floodplain in the area of Neuburg and Ingolstadt possible. Using ground-based LiDAR and photogrammetry tools, hydromorphological characteristics were investigated in different reaches and habitats. For all habitats enhanced eco-hydromorphological dynamics was proven. DanubeSediment is an international project funded by the Danube Transnational Program. It aims at finding solutions to improve sediment quality as well as sediment transport from a basin-wide perspective. In this issue of Danube News, Hanna Skiba and co-authors from Germany, Austria, Hungary, Slovakia and Romania provide a brief overview of the project. They describe sediment data collection, the identification of key drivers of sediment continuity and they offer an outlook on developing a sediment guidance and a stakeholder manual as major outputs of the project.

The news and notes section presents three short articles on the discovery of a new copepode species in groundwaters of Germany (Santiago Gaviria), conclusions from microbial faecal pollution monitoring during JDS 3 (Alexander Kirschner) and nutrients assessment in the Romanian Danube (Carmen Postolache).

Hydro-power dam Bergheim/Bavaria. One of hundreds of dams along the Danube that block fish migration and sediment transport and call for projects reported by Skiba et al. and Fischer in this issue. © Aueninstitut Neuburg

Near-natural bypass channel development: focus on a highly dynamic river reach in the MONDAU project area between Neuburg and Ingolstadt

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Introduction

The aims and measures in river restoration projects are multifarious. For example, one prevalent measure to improve the longitudinal connectivity is the installation of a fish migration pass (nature-like fishway). Constructed fishways that imitate morphodynamic components of natural fish habitat, such as substrate clusters, shelters, pools, riffles in rivers and streams, may provide a fully functioning surrogate habitat for a wide range of organisms living in the river or at the riverside. Side channels for upstream migration also affect all other components of hydromorphological conditions such as morphology, hydrology, physical and riparian habitats, therefore, often referred to as eco-hydromorphological conditions. As a matter of course, lateral connectivity is usually influenced as well and even the two other dimensions of hydrological connectivity, vertical and temporal connectivity, always play a major role in a holistic approach of riverscape restoration.

In the MONDAU (MONitoring DonAUauen) project area, one of these side channels was established as a key component of the local restoration project.

The state-of-the-art in science and technology about fish migration and bypass structures is for example presented in the DWA (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.) information sheet 509 (DWA 2014). In Bavaria a practice handbook is available online (http://lfvbayern.de/download/fischaufstiegsanlagen-in-bayern). Katopodis & Williams (2012) give an insight into the development of fish passage in a historical context. The paradigm shift from mere keeping chemico-physical values to simultaneously saving and improving the ecological status required by the European Water Framework Directive (EG WRRL 2000) revealed a new interdisciplinary field. Howsoever, to improve connectivity in rivers four elements are involved:

1. water
2. sediment and bedload
3. fish and benthos
4. vegetation (plants and deadwood)

In the meantime, self-dynamic development and hydromorphological assessments are common terms in restoration projects and/or explicitly required. Planning and construction of a bypass is still elaborate and costly and it is uncertain whether the desired dynamic will be generated. A near-nature style is recommended to maximize the variety of structures. In well-functioning rivers, sediment transport and deposition lead to a variety of habitats, the classic mosaic structure. And in dependence on irregular floods, also banks and surrounding floodplain have always been in constant change. Attributes for the ecological functioning of natural rivers and streams can also be applied to side channels:

- dynamic (environmental) runoff and transfer of sediments
- migration of fishes and benthos
- highly diverse instream habitats and structure elements
- interaction and connectivity of side channel and surrounding

Finally, features for functional rivers are well known, but self-development forecasts and minimum standards are still unsatisfactory. But running water, at any given location, can no longer be managed without an active understanding of the drivers and impacts of the three other elements (see above). Without a sound knowledge of the structures and biocoenosis of semi-natural streams it is not possible to properly assess degraded streams or to plan their successful “restoration”. To support the understanding of fluvial eco-hydromorphological process dynamics, point clouds (derived from the terrestrial laser scanner) and orthophotomosaics (derived from unmanned aerial vehicles) are used as a basis for mapping.

Study site and MONDAU restoration project

The investigated stream reach is part of the fish migration bypass system “Ottheinrichbach”. This is situated in the MONDAU floodplain area of the Upper Danube River segment between Neuburg and Ingolstadt (between kilometers 2473 and 2464, *fig. 1)*. Between two hydropower dams, there are around 1200 ha of high biodiversity riparian forests with individual endangered floodplain species (Cyffka et al. 2016). The altitude is about 372 m above sea level with local relatively steep steps to the next postglacial terrace or meander scars. An average annual precipitation of 744 mm and an average mean temperature of 8.8°C is being recorded at surrounding weather stations. The daily discharge at the gauging station “Ingolstadt Luitpoldstraße” is listed in table 1. A detailed description of the hydrological regime and the Danube floodplain formation is given by Fischer (2016).

Reduced connectivity between the Danube and its backwaters has fostered tendency towards terrestrialization and changed groundwater table and dynamics. Natural floods hardly reach the floodplain, due to the constant degradation (bed erosion) and the dropping water level. There were no

Danube	
MNQ (low water)	131 m³/s
MQ (mean)	311 m³/s
MHQ (high water)	1.120 m³/s
HQ5	1.320 m³/s
Bypass system Ottheinrichbach	
Water level dynamics	2,44 m
MQ (mean)	2,1 m³/s

Table 1. Mean discharge at Ingolstadt gauging station (1924–2014) and gauge 10 (2010–2014, see fig. 1)

significant fluctuations in water levels and sediment dynamics. The nowadays fixed channel structure and standardized flow conditions have led from a former dynamic to a rather stable and well-balanced situation in the riparian ecosystem.

The pre-restoration state, technical preconditions and expectations are described by Stammel et al. (2011). First results presented by Fischer & Cyffka (2014) and the final report are available in the NaBiV (Naturschutz und Biologische Vielfalt (Nature Conservation and Biodiversity)) series 150: “Neue dynamische Prozesse im Auenwald” (Cyffka et al. 2016). A short explanation of the three restoration measures of the MONDAU project is provided here:

- The bypass called ‘Ottheinrichbach’ runs through the floodplain. Depending on the Danube discharge, a water volume from 1.0 up to 5.0 m^3/s is provided by the Danube. Within the first 2 km a completely new nature-like channel was carved into the alluvial sediments and old (dry) meanders (and the AOI (Area of Interest) as well). The following 6 km the river uses pre-existing water bodies like former oxbows and other temporary water bodies.
- Controlled floodings with an additional amount of 25 m^3/s of water, equally controlled by a sluice, depending on a peak discharge of the Danube of 600–1000 m^3/s, statistically take place 2–3 times a year for a few days.
- Groundwater draw-down in the eastern project area during low water conditions (Danube runoff <150 m3/s, MNQ in summer): A gate *(fig. 1)* in combination with stoplogs and a diversion trench allows a lowering of the groundwater level to amplify the hydrological dynamics.

The overall goal of the project is to bring back hydrological dynamics as a key process at least to a part of the floodplain in order to achieve better interaction between Danube, riparian zone and floodplain and to improve natural dynamics along the near natural fish bypass system. The controlled flooding was designed to bring water into the whole area as well as to initiate erosion at the river banks and bring new dynamics to the channel belts to create “natural site conditions”.

All surveys were conducted at one of the return flows of the nature orientated stream (bypass system). The entire length of the investigated river reach is about 220 meter, from the bridge to the river mouth *(fig. 2)*. The channel with a mean discharge of 1.6 m^3/s (more or less half of the complete discharge volume of the bypass) is carved into sediments and has an average slope of 0.4%. This place is the favourite location for fish to enter the bypass and has meanwhile become a natural spawning ground for sundry species (Pander et al. 2015).

The upper part, close to the bridge, is widened and a scour established in 2013. In front of the bridge, a huge amount of fallen wood as colonisable substrate has accumulated (since 2014). A mid-channel gravel bar has piled up in the centre (since 2012 and still under development),

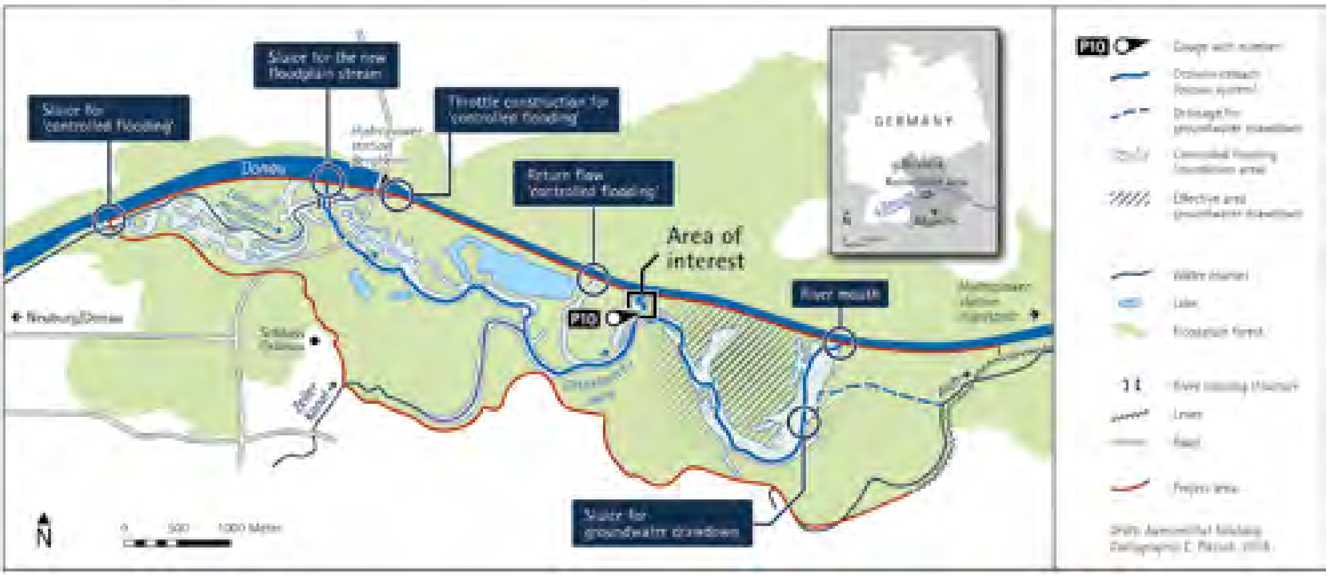

Figure 1. Simplified map of the study area and location of the measures (new floodplain stream, controlled flooding and groundwater draw-down) and the area of interest with gauging station “P10” for water level measurements

Figure 2. Stream reach from the bridge to the river mouth. Diverse instream structures and the new depositional gravel bars and the complex deadwood structure in front of the bridge, formed by the last flood event (photo P. Fischer).

followed by an 80 m section with a 65°-curve and a bank-attached bar. In the last 40 meters, close to the river mouth, the slope rises up to 1.5 % in combination with or therefore a highly dynamic undercut bank on the right hand side has accrued (formed and reworked with every flood event). On the opposite side, meanwhile, a compound bank-attached gravel bar (reflecting a range of various flow conditions) has developed. In short, a very dynamic reach with a large number of instream geomorphic units.

Tools and methods

Eco-hydrogeomorphic measurements using ground-based LiDAR and photogrammetry tools:

During the last decade, the application of ground-based LiDAR data in geomorphology, and especially in fluvial research, has rapidly increased (Heritage & Large, 2009), as high resolution Digital Terrain Models (DEMs) can be used to quantify the change of fluvial landforms and river morphology (e.g. bars, bank failure and other geomorphic units). Unmanned Aerial Vehicle (UAV) photogrammetry and Structure from Motion (SfM) processing can now be used as a basis for mapping research sites (Flener et al. 2013, Javernick et al. 2014, Eltner et al. 2015). In this contribution, a simple, convenient way to quickly produce mapping bases for a highly dynamic river reach was chosen.

To document the morphological changes – the sediment shifting processes in the channel and self-dynamic development of the water course – a combination of two methods (data sources) was used in this case study. The channel reach was actually well surveyed for a PhD thesis between 2010 and 2014 using a terrestrial laser scanner for generating high resolution digital elevation models (Fischer 2016). Thus, the point cloud was reused in a top view perspective as a basis for mapping instream structures and bank line development for the first period *(fig. 3, top left)* and changed to UAV photogrammetry for the second period to ensure further bank retreat monitoring *(fig. 3, top right).*

Tools for data acquisition

TLS-system: Terrestrial Laser Scanning was conducted with a Riegl LMS Z420i. This long-range 3-D laser scanner has a maximum measurement range of up to ~ 700 m and the distance accuracy is 0.01 m (by single shot). To detect colour information, the scanner is equipped with a mounted digital SLR camera (Canon 350D, Nikon D70).

UAV-system: aerial image acquisition was done with a DJI Phantom 4, a low cost quadrocopter with an integrated camera.

Methods (workflow in field and office) for data acquisition

TLS-system: the scanning system is operated with the software RiSCAN PRO by Riegl on a tablet PC, and for post-processing steps the same software was used. 1–2 scanpositions were selected to cover the cut off bank (Fischer 2016), and 4–8 positions were needed to cover the area of interest. For one scanposition, including re-arranging and scanning tie points, about 45 minutes are required. So, total data acquisition takes around 5 hours. TLS data have been acquired over a period of three years between October 2010 and April 2013. Permanently fixed tie points were used to co-register point clouds from different scan positions and surveys. For post-processing, several steps are necessary (e.g. Haas et al. 2016); vegetation and artificial objects and flying points (e.g. insects and birds) were deleted. The final point cloud can be used in GIS as mapping basis *(fig. 3, top left).*

In this contribution, a rather rare approach pulled up in practice. Because of inadequate data quality for change detection and volume calculation in a satisfied manner (point density, gaps or distortion), the decision was taken to use top view 2 D data instead of 3D point cloud data.

UAV-system: Ground Station Pro (App, 1.6.0) was used for flight planning and for controlling the UAV with an external tablet iPad. The images were collected at flying heights of about 50 m with an overlap of 85 % (front) and 75 % (side) in order to capture the complete river reach in less than 5 min. The ground sampling distances after processing is 2 cm for the orthophotomosaic. In total, 110 images were taken during each flight. The final products, orthophotomosaics, were created using the software PhotoScan Professional by Agisoft. The photogrammetric software produces 3D spatial geodata from digital imagery using a SfM workflow (i.e. Javernick et al. 2014, Eltner et al. 2015, Haas et al. 2016). The orthophotomosaics were also used in GIS as mapping basis *(fig. 3, top right).*

In highly dynamic riverscapes, multitemporal measurements are sometimes required during one day. So, the use of UAV seems to be a very efficient way for data acquisition. Aerial images and orthophotomosaics present a view of the features of the study site and they offer a useful method for creating new maps. Maps are updated by digitizing the features from the mapping basis.

Results and discussion

The dynamic discharge (measured at gauge 10, P10 in *fig. 1)* and varying flow directions (at discharges > 850 m^3/s the flow direction rotates) cause erosion and deposition along the water course, thereby generating continuous alteration to the river reach. In addition to the width variability, the depth variability is also high in single cross sections, as well as throughout the examined reach. The morphology reflects the balance of erosion and deposition processes occurring along the bank and bed. Sediment shifting processes in the bypass were measured by mapping instream structures. Both differentiation and development of new habitats could be ascertained. Deadwood elements have proven essential to increasing the structural variety of the river, aggregations in some cases leading to pool formations which changed the depth variability along the riverbed.

In the first period (42 days after opening), only one controlled flooding took place and the bank line reacted at a few stretches only, where changes were visible *(fig. 3, centre left side).* Due to the water level, a decrease of river width is indicated in the data. In the survey of 22nd April 2013, after 271 days and six flood events, a clear difference is visible when comparing the orange and blue line *(fig. 3, centre left side).* The channel widening appears on both sides over the whole stream reach. The bank line is now separated in small inlets and “micro” cut banks (concave bank) and slip-off banks (convex bank). In figure 3 (centre left and right side), the widening of the stream from 2013 to 2017 is apparent, particularly in the first part of the reach. Bank retreat changed during the last period from 2017 to 2018, affected by the last flood event from 19th to 22nd of January *(fig. 3, centre right side).*

Looking at instream structures like mid-channel and bank-attached bars and deadwood accumulation, massive changes can be observed. In this contribution, only the bigger ones (> 1m^2/s) have been focused on. As a result of river widening, gravel bars and a relatively big island were formed. All structures that can still be seen developed on their own and were not artificially created. The deposition zones are e. g. visible in bright areas in the orthophotomosaic *(fig. 3, top right side).*

In the following, three different patches or geomorphological units are picked out *(marked with red cycles in fig. 3, top right).* Understanding the changes compare *figure 3,* bottom left and right side:

I: The “new” gravel island just a few meters downstream behind the bridge, close to the scour: In the early days, the unusual composition of materials was conspicuous, because it primarily consisted of river engineering stones which were introduced by river training measures. Sorting, however, ranges from boulders and cobbles at the top to pebbles at the end of the island (downstream size decreases).

After the first formation phase, a mid-channel teardrop-shaped structure, then a mid-channel bar similar to a transverse bar had established before a little vegetated bar formed. The primal establishment of pioneer vegetation took place in summer 2012. This stabilisation induced further sedimentation. Nowadays the structure is “young”, but a real gravel island, because even floods (natural or controlled) are not strong enough to remobilise the material. Just small gravel is rearranged. Vegetation has a stabilising effect and fosters the vertical growth of the island e.g. with deposition of foliage and other floating debris.

II: The bank-attached bar, previously composed of gravel, at present of coarse sand, located in the 65°-curve: the scroll bar developed between July 2012 and April 2013 (in fact during the “Christmas flooding 2012”) along the inner bend. Today it has a very long shape running parallel to the bank line, and it is self-designed by two-dimensional flow paths (helicodial flow). At this patch, a significant material sorting in flow direction could be observed. Fluvial entrainment and undercutting are the dominant bank erosion processes. A more or less single gravel bar

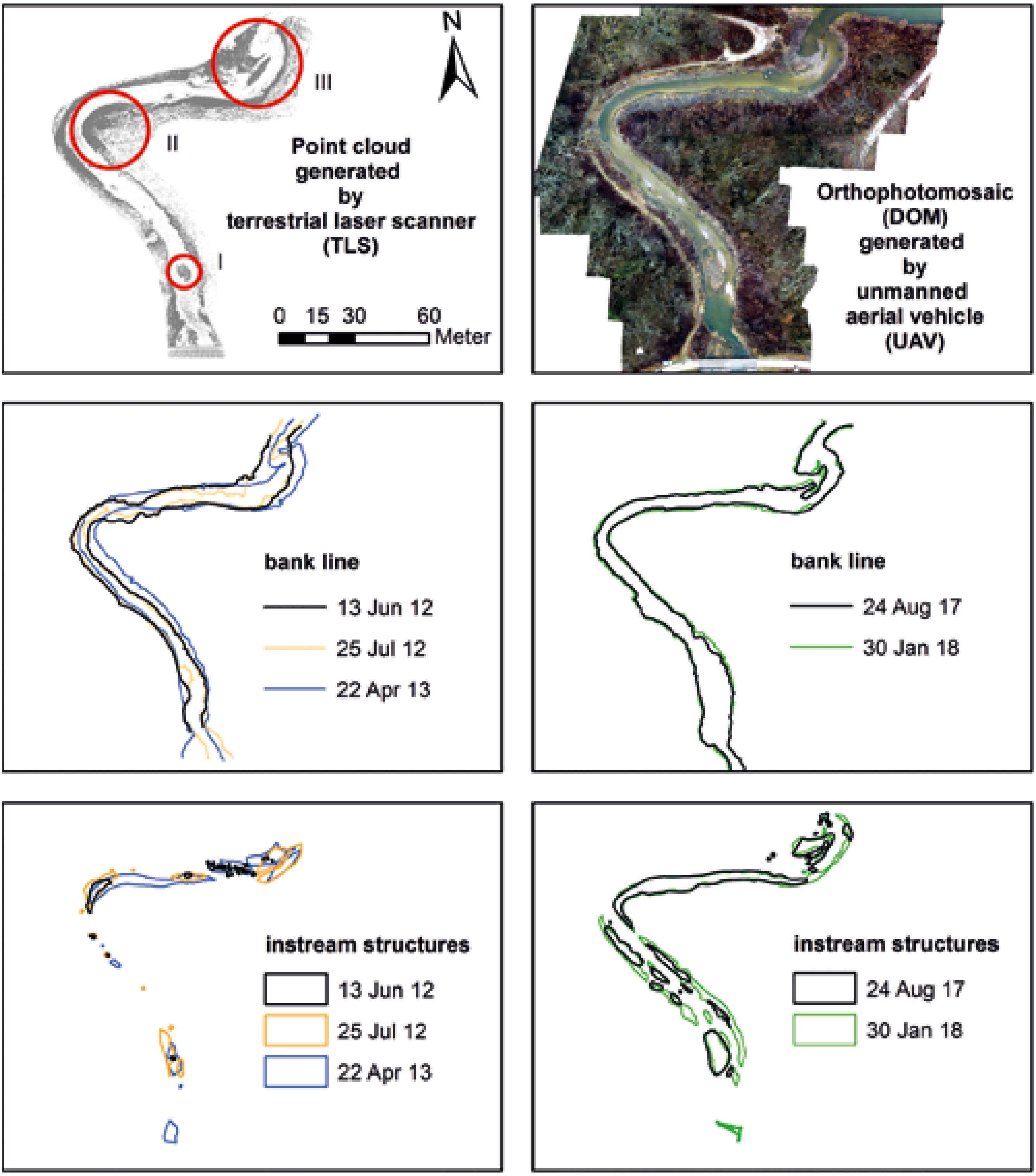

Figure 3. Erosional and depositional features along the stream reach: top left: 3D point cloud generated by a Terrestrial Laser Scanner (TLS) with red marked area of interest, top right: orthophotomosaic generated by Unmanned Aerial Vehicle (UAV), center left: digitized channel course (TLS-data), center right: digitized channel course (UAV-data), bottom left: digitized instream units (TLS-data) and bottom right: digitized instream units (UAV-data).

transformed into a bank-attached parallel sand bar. The initial bar *(fig. 4)* made up of gravel, becomes a fine material layer directly in the inside bend. The longitudinal extension ranges from 15 m on June 13th 2012, over 18 m, 53 m, 90 m to 105 m on January 30th 2018

III: The expanded gravel bar close to the river mouth: composed of local sediments which were eroded upstream. A structure that comprises an array of smaller scale units like chutes, channels, ramps or ridges. The bar may be reworked by every flood event or sediment deposited by temporary flow obstructions. At low flow conditions, especially decreasing limb fine deposits cover the top of the bar. Continuous development leads to a more than 60 cm thick sediment layer. The outer bend of the point bar follows the bank retreat of the cutoff bank. The concave bank follows the typical cycle of bank retreat with mass failure (slab failure and sloughing) and toe accumulation.

Hydrologic investigations were carried out through a nearby gauging station to record vertical water level variations over the whole period. In response to channel widening and scouring, a shift in water level measurements was recorded in summer 2012. At the selected locations, different processes were observed due to further influencing factors (vegetation, substrates, etc.). Noteworthy among these processes is that numerous locations showed a rapid development particularly in the early stages of observation. Various bar structures were created during that time, occurring in several activity phases.

Conclusion

The semi-natural bypass acts just like a natural river, shifting its course and creating new structures. Nevertheless, the man-made status will always remain, shown for example in an unnatural runoff, strongly changed sediment transport rates and sediment characteristics. A development of a secondary floodplain, a narrow riparian margin, will occur at topography lower than the Danube floodplain and on very limited space. This element is also an irreplaceable part of a semi-natural stream, but even in the early stages, this self-improved floodplain has developed habitats with eco-hydromorphological dynamics for typical floodplain species and will continue to do so. This significant potential opportunity can be realised through clever water body and floodplain development.

The use of TLS and, in particular, UAV data for river structure mapping is a helpful tool for improving the understanding of eco-hydromorphological processes and for the application of assessment methods. However, there is a clear relation between technical capability, resources and availability of time. The researcher needs to strike a careful balance between these variables.

Nature-orientated hydraulic engineering, limited to the creation of undercut slopes, gravel bars and deadwood structures is not enough to revitalise such ecosystems. River habitats are generally controlled by physical processes (flow, water quality, sediment transport). So we can make big changes to the biodiversity of rivers by managing (or mis-managing) the flow. Rather, the dynamic processes and the driving forces leading to these structures must be promoted. Therefore, a new bypass system with man-made discharge variations is not enough to successfully restore a floodplain. But hundreds of kilometres of many "small streams" and their accompanying small secondary floodplains will have an impact.

Figure 4. The stream reach with the bank-attached gravel bar in January 2012.

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DanubeSediment – Transnational Cooperation for Sediment Management in the Danube River

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Interreg
Danube Transnational Programme
DanubeSediment

Sediment management – a common challenge along the Danube River

Sediment transport is an integral component of every river system *(fig. 1)*. It influences a wide variety of sectors dependent on the river such as navigation, flood risk, hydropower production, agriculture, tourism, water supply and the habitats of flora and fauna.

Even the first direct human interventions during the late Middle Ages had a notable impact on the sediment regime of rivers, for example the increasing importance of inland waterway navigation lead to man-made alterations of the river bed and banks, thereby increasing the flow velocity of the water. Dike systems for flood protection, or the construction of hydropower plants in the Danube and its tributaries have led to the current situation, which is characterised by the replacement of natural dynamic processes with unidirectional developments, ongoing incisions of the river bed, sedimentation in floodplains, terrestrialisation, and missing regeneration of typical floodplain habitats and their riparian vegetation (Hohensinner 2015).

Figure 1. Estuary of the Isar entering the Danube; Source: www. agroluftbild.de.

The EU Water Framework Directive (WFD, 2000/60/EC), which entered into force in 2000, recognizes rivers as ecosystems that have to be protected and enhanced. In the Danube River Basin, the ICPDR (International Commission for the Protection of the Danube) provides the platform for the implementation of all transboundary aspects of the EU WFD and the EU Flood Directive (EFD, 2007/60/EC).

In order to implement the WFD, ICPDR developed the Danube River Basin District Management Plan (DRBMP) in 2009 and updated the plan in 2015. The DRBMP 2009 stated that "sediment balance of most large rivers within the Danube River Basin can be characterised as disturbed or severely altered. Morphological changes during the last 150 years due to river engineering works, torrent control, hydropower development and dredging, as well as the reduction of adjacent floodplains by nearly 90%, are the most significant causes of impacts." (ICPDR 2009, p 25; ICPDR 2015, p 45).

The DRBMP therefore proposes to establish a sediment balance for the Danube River Basin and to provide sufficient data for this approach. The sediment continuum must be ensured by improving existing barriers and avoiding additional interruptions. Further investigations are needed to identify the significance of sediment transport on the basin-wide scale of the Danube River.

The updated DRBMP of 2015 announced the preparation of a transnational project as necessary to improve the "availability of sufficient and reliable data on sediment transport". The project should develop a "sediment balance" and assess what "additional investigations are needed to identify the significance of sediment transport on the Danube basin-wide scale" (ICPDR 2015, p 45).

In January 2017, the work on these tasks began in the frame of the DanubeSediment project, funded by the Interreg Danube Transnational Programme (DTP). For a period of two-and-a-half years, 14 project partners from higher education institutions and sectoral agencies in 9 countries along the Danube River are collaborating to collect sediment transport data in the Danube River and its main tributaries, to set up a Danube-wide sediment balance, to identify the key drivers of sediment discontinuity as well as the collection of measures that enable a more sustainable sediment management in the Danube River Basin.

As the sediment in the Danube River is managed by a wide range of stakeholders across many countries, transnational cooperation between the different sectors is vital. To develop a sustainable approach, the stakeholders require a good knowledge of sediment processes and tools for joint action on sediment management. The DanubeSediment project will therefore provide a Danube Sediment Management Guidance (DSMG) with key recommendations for reducing the impact of a disturbed sediment balance, e. g. on the ecological status and on flood risk along the river. These recommendations will be fed into the Danube River Management Plan (DRBMP) and the Danube Flood Risk Management Plan (DFRMP).

To directly address the specific needs of the key stakeholder groups, a Sediment Manual for Stakeholders will provide sector-specific know-how and include good practices examples for sediment management in the Danube Basin, e. g. for navigation, hydropower, flood risk and river basin management including ecology.

The collection of sediment data in the Danube River and its main tributaries

In a first step, the project partners established an inventory of metadata about sediment monitoring stations for suspended sediment as well as bed load measurements along the Danube and near the mouths of the major tributaries. The metadata spanned historical and present times. Each project partner provided information on sediment monitoring, as well as on laboratory analysis and sediment load calculation methods applied in their country. This data collection was managed via web-based questionnaires. The collected metadata was then summarized in a report, including tables and base maps that indicate the sediment monitoring practice of each country.

During the second half of 2017, the partners collected sediment data. Suspended sediment load data was gath-

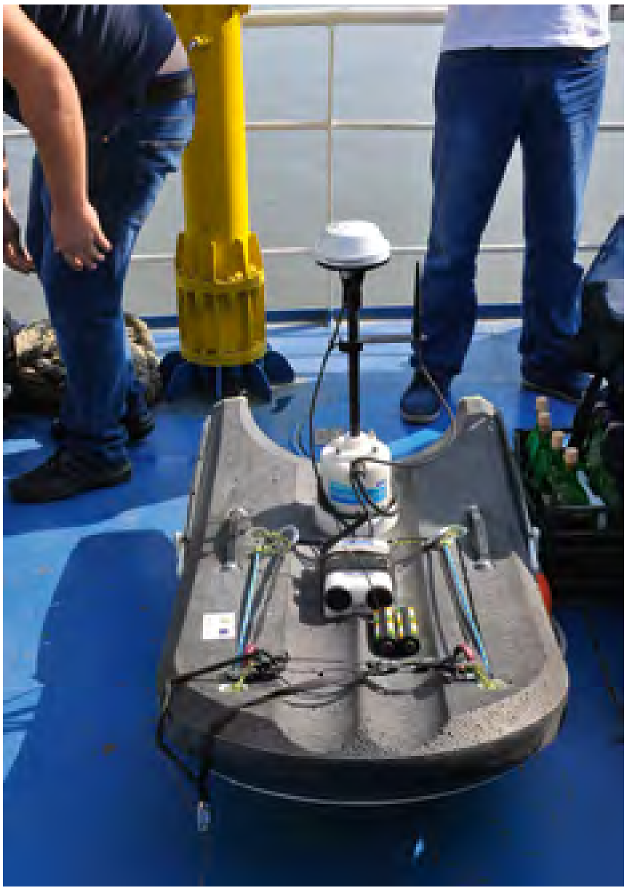

Figure 2. An Acoustic Doppler Current Profiler measures flow velocity and water depth, which are needed to calculate the discharge in a cross section. Source: Marlene Haimann / IWHW – BOKU

Figure 3. *Sampler in Bulgaria using the depth-integral method. Source: Marlene Haimann / IWHW – BOKU*

ered on a monthly basis, covering the period of 1986–2016. For recent flood events, load values were gathered on a daily basis. Information on suspended sediment was provided for 41 stations along the Danube and for 20 stations from the tributaries. Bedload data was assessed at 22 stations.

In order to reveal sediment data uncertainty and possible bias in the datasets, a comparative analysis of the sediment data was performed. The analysis consisted of two parts:

i) comparison of historical sediment data collected at Danube sections shared by two countries, such as Hungary – Slovakia, Serbia – Romania and Romania – Bulgaria;

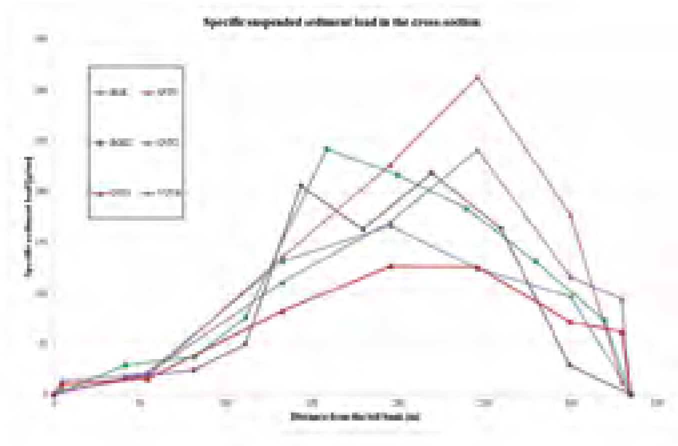

Figure 4. *Comparative analysis showing the cross-sectional distribution of specific suspended sediment load measured by project partners with different methods at the measurement site: Danube, Bad Deutsch-Altenburg, Austria. Source: Sandor Baranya, unpublished*

ii) comparison of sampling methods *(fig. 2, 3)* in the frame of joint field measurement campaigns. The results of the comparative analysis contributed to the elaboration of good practices in sediment monitoring *(fig. 4).* The latter information will be compiled as a handbook that will be made available to interested parties.

Using the collected and analysed sediment datasets, longitudinal and temporal variations of the sediment load are in the process of being assessed. The quantified analysis of sediment transport along the Danube will produce key results for the project goals. For example, the sediment data will reveal sections that present problems for sediment continuity, such as reaches with significant bed erosion or sedimentation. Furthermore, the collected data can contribute to analyse the impact of hydropower plants or floods on sediment continuity.

Towards a Danube-wide sediment balance

In a first step towards the evaluation of the sediment balance, project partners checked the availability and accessibility of present and historical data. This information is also needed to understand the influence of long-term morphological developments of the Danube River on the sediment regime.

In order to calculate the sediment balance, the data collected on the suspended sediment load (see above) was complemented by data on morphological characteristics of the river channel, e. g. bathymetry, longitudinal profiles, minimum navigational water levels, dredging / feeding amounts, bed material and bed load composition. This data has been deployed for three time periods: 1920–1970, 1971–1990 and 1991–2016. Each period is characteristic for different degrees of river channel modification.

Another important component of the sediment balance is the quantification of morphological changes, e. g. areas of erosion and sedimentation or the slope of longitudinal profiles. Depending on the availability of underlying data, these bedload parameters were provided for shorter river reaches and several time periods. In case this bedload transport data is insufficient or missing, the volumes of river bed aggradation / degradation are needed.

In general, the sediment balance analysis covers three morphologically different river sections: Upper Danube, Middle Danube and Lower Danube, as well as the selected tributaries. In selected Danube river reaches for which more data is available, a small scale analysis will be done.

In order to analyse the long-term morphological development of the Danube in the context of sediment balance changes, historical maps from the end of 19th century were compared to the present state (2016/2017): Information gathered in this step, such as the modification of the river pattern and the river bed slope, the narrowing and shortening of the active river channel, spatial and temporal changes of sediment composition, has been quantified to identify changes in the river processes and morphological characteristics of the Danube channel. This gives an under-

Figure 5 and 6. DanubeSediment Stakeholder Workshop held in Germany (bottom) and Austria (top); Source: LfU (bottom) and Marlene Haimann / IWHW – BOKU (top)

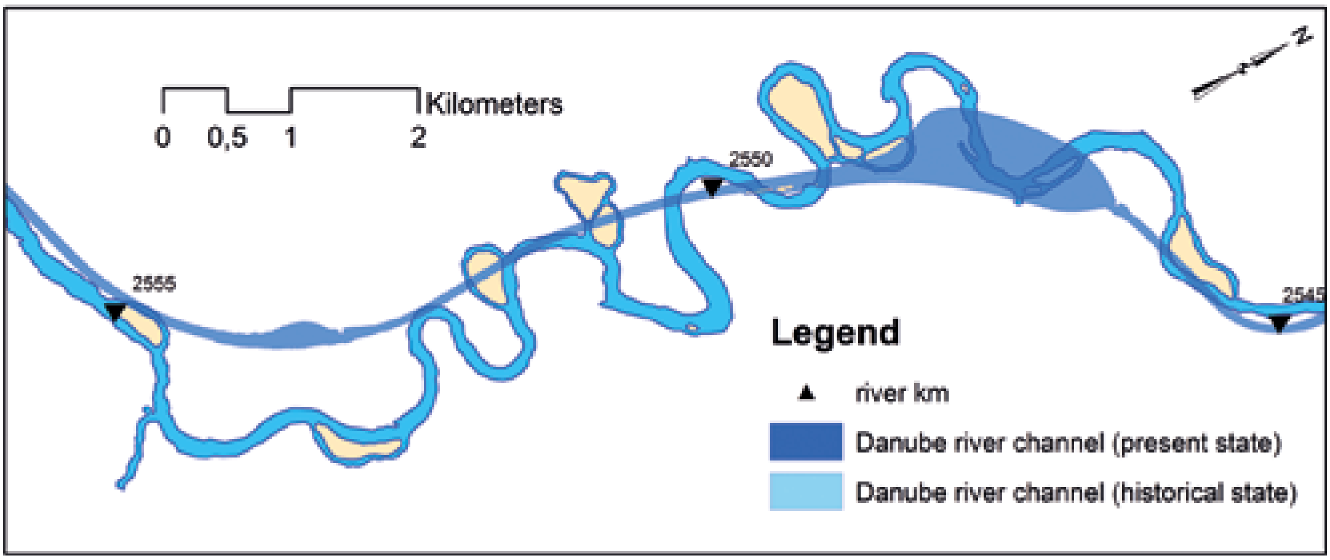

Figure 7. Shortening of the Danube river in Germany; source: VUVH

standing of the degree of hydromorphological alteration in the Danube River.

Determination of the key drivers of sediment discontinuity

Based on the DPSIR (Driver-Pressure-State-Impact-Response) method, past, present and future developments of key drivers causing changes in the sediment balance of the Danube and its selected tributaries (Isar, Inn, Traun, Enns, Morava, Lajta, Raba, Vah, Drava, Tisza, Sava, Velika Morava, Jiu, Iskar, Yantra, Arges, Ialomita, Siret, Prut) were analysed. For that purpose, project partners gathered information by qualitative questionnaires: A total of 33 questionnaires were filled out, one for each national section of the Danube and one for each national tributary. Additionally, the key drivers were collected as GIS-shapefiles.

A first analysis of the data shows that navigation, flood protection and hydropower are considered as the main

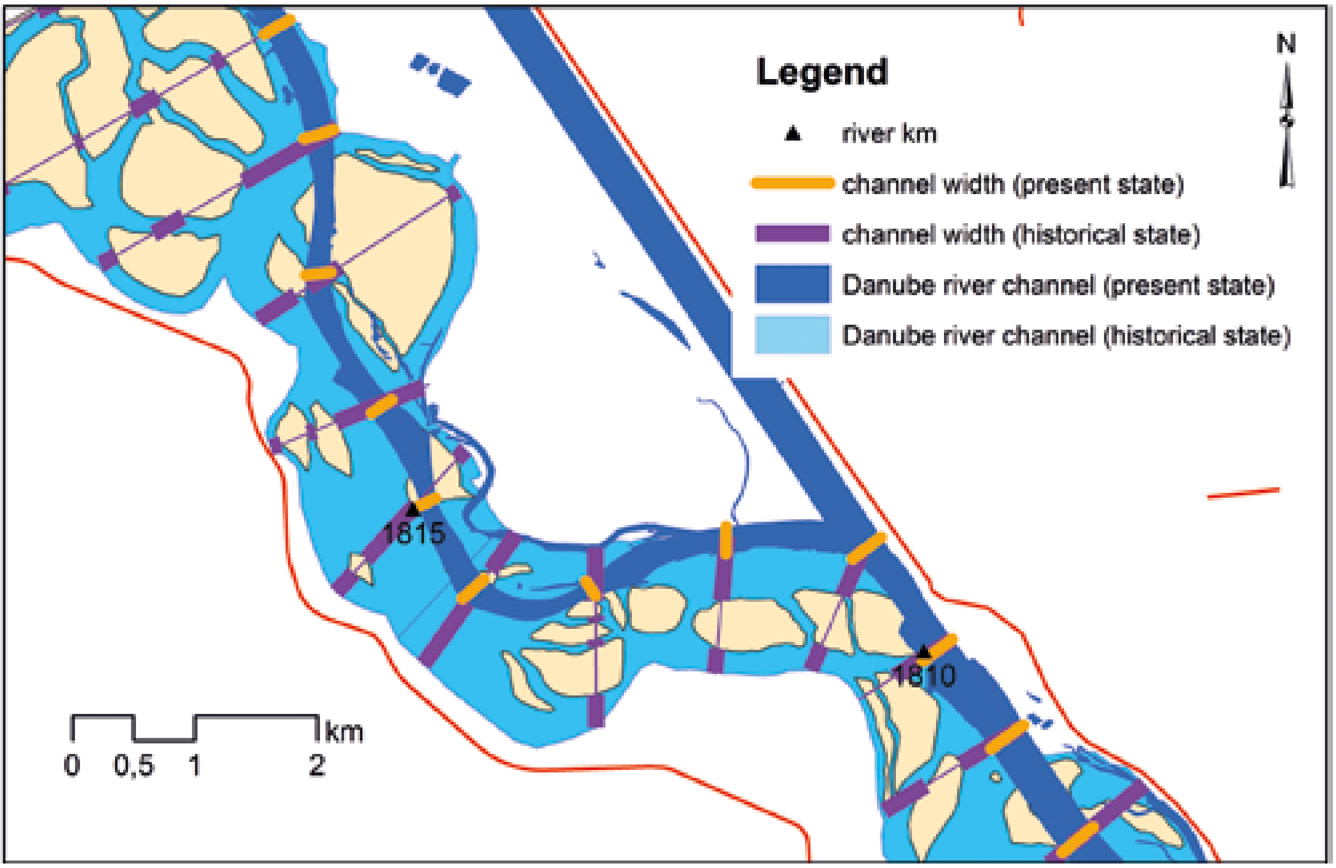

Figure 8. Changes of the Danube river channel width in Slovak – Hungarian section; source: VUVH

drivers for changes of the sediment regime on a Danube Basin level. Furthermore, agriculture and water supply (for drinking and industrial purposes) have been identified as important drivers, though the interaction of agriculture and sedimentation could only be considered on a limited basis within this project. Previous studies have shown that the influence of agriculture on quality issues of sediment is particularly high – an issue that is outside the scope of the DanubeSediment project.

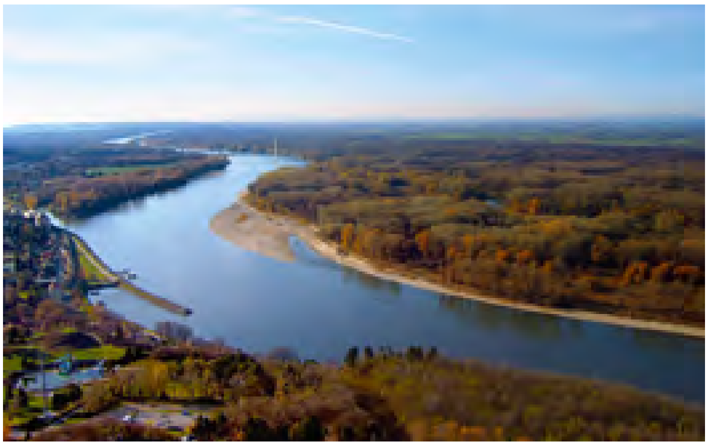

Figure 9. DanubeRiver, east of Vienna, view from Braunsberg; Source: Philipp Gmeiner, IWHW-BOKU, Vienna

A sediment guidance and a stakeholder manual for the Danube River

Based on the knowledge and insights gained during the activities described above, which are flanked by an active and regular stakeholder involvement via workshops on national and international level *(fig. 5, 6)*, the project will produce a Danube Sediment Management Guidance (DSMG) and a Sediment Manual for Stakeholders (SMS).

The DSMG will be a strategic document for decision-makers that seek to improve awareness on sediment quantity-related problems. It will suggest measures for solving sediment-related problems in the Danube River Basin, such as the impacted ecological status and the increasing flood risk. The document will provide a strategy for better sediment management, such as improving the sediment continuity as well as reducing the gap between surplus and deficits of sediments, directly contributing to improved transnational water management and flood risk prevention.

The Sediment Manual for Stakeholders (SMS) will support the guidance document by providing detailed and stakeholder-oriented background information and complimenting it by concrete examples of measures. The SMS will give suggestions for the future planning of sediment management measures and describe sediment-related good practice examples. To address the key stakeholders, the manual will focus on hydropower, navigation, flood risk management and river basin management, which includes ecological issues. Stakeholders such as companies responsible for waterway maintenance, hydropower plant operators or nature protection can benefit from the recommendations made in the SMS, e. g. about new sediment management methodologies, which can be directly implemented into their operation and daily business. A specific chapter of the manual will discuss the importance of multi-stakeholder interrelation and transnational co-operation to tackle the issue of sustainable sediment management. The Danube Sediment Management Guidance and the Sediment Manual for Stakeholders will contribute to the next Danube River Basin Management Plan and the Danube Flood Risk Management Plan.

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News and Notes

Comparison between long-term monitoring survey data and "snap-shot" data from investigative monitoring of Joint Danube Surveys – Case study for nutrients along the Romanian stretch of the Danube River

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The assessment of nutrients in the Danube River has a well-known long-term history at the basin-wide level, especially in view of the link between the nutrient loads of the Danube and the eutrophication of the Black Sea. Therefore, monitoring the pressures given by nutrients in the Danube River Basin District and the extent to what the nutrient loads into the Black Sea are being reduced is one of the major objectives of the comprehensive monitoring activity carried out by the Danubian countries within the frame of Trans-National Monitoring Programme (TNMN) of the International Commission for the Protection of the Danube River (ICPDR). Tailored as a long-term surveillance monitoring, TNMN provides a general overview of the selected water quality parameters in terms of concentrations and loads, mainly in transboundary context. On the other hand, even if according to the Water Frame Directive investigative monitoring is primarily a national task, at the basin-wide level ICPDR launched the concept of Joint Danube Surveys (JDS), carried out every six years, starting from 2001. One of the specific objectives of the investigative monitoring surveys is to increase the comparability between a homogenous data set produced by a single sampling procedure and laboratory analysis (JDS measurements) and data generated by long-term surveillance type of monitoring (Trans-National Monitoring Network data) carried out by the basin-wide network of TNMN laboratories from each Danubian country.

In a case study carried out in Romania, we intend to provide a comparative view of the surveillance TNMN data and investigative data obtained during the three monitoring programmes known as Joint Danube Surveys 1, 2 and 3, carried out in 2001, 2007 and 2013 respectively. In order to have an optimal way of data comparison and given the survey timing of JDSs (August – September), the momentary results obtained during the three investigative surveys are compared with mean, median and 90-Percentiles of the TNMN data set from August – September during 2001 – 2013.

Microbial Faecal Pollution in the River Danube is Predominantly from Human Sources

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In 2013, the International Commission for the Protection of the Danube River (ICPDR) organized the 3rd Joint Danube Survey to investigate the water quality along the total length of Europe's second longest river. As part of the survey, researchers from the Interuniversity Cooperation Centre Water & Health in Austria (Technische Universität Wien, Medical University Vienna, Karl-Landsteiner-University Krems) and the University of Belgrade, monitored microbial faecal pollution levels by standard faecal indicator bacteria along a 2,580 km stretch of the Danube, as well as in the Danube´s most important tributaries. To track the origin of faecal pollution, host-associated Bacteroidetes genetic faecal marker qPCR (quantitative polymerase chain reaction) assays for different host groups were applied in concert with standard faecal indicator bacteria (SFIB). The spatial resolution analysis was complemented by a time resolution analysis of faecal pollution patterns over one year at three selected sites (downstream the cities of Vienna, Budapest and Belgrade). In this way, a comprehensive faecal pollution map of the total length of the Danube was created, combining substantiated information on both the extent and origin of microbial faecal pollution. Samples were taken midstream of the river and near its right and left banks. Midstream samples representatively depicted the microbial pollution levels at the respective river sites. However, at a few, somewhat unexpected sites (no apparent point sources or larger settlements), high pollution levels occurred in the lateral zones of the river while the midstream zone had good water quality. Using host-associated molecular markers human faecal pollution was demonstrated as the primary pollution source along the whole river, while animal faecal pollution was of minor importance. This study demonstrates that the application of host-associated genetic microbial source tracking markers in combination with the traditional concept of microbial faecal pollution monitoring based on SFIB significantly enhances the knowledge of the extent and origin of microbial faecal pollution patterns in large rivers. It constitutes a powerful tool to guide target-oriented water quality management in large river basins and is a prime example for the value of broad scientific transnational cooperation. For the upcoming Joint Danube Survey in 2019, the research team together with colleagues from the Medical University Graz plan to investigate the link between faecal pollution patterns and the distribution of antibiotic resistance in the Danube.

This mentioned study was recently published in the Journal Water Research:

Kirschner AKT, Reischer GH, Jakwerth S, Savio D, Toth E, Ixenmaier S, Sommer R, Mach RL, Linke R, Eiler A, Kolarevic S, Farnleitner AH (2017) Multiparametric monitoring of microbial faecal pollution reveals the dominance of human contamination along the whole Danube River. Water Research 124: 543–555

Discovery of a new species of Moraria *(Copepoda, Harpacticoida, Canthocamptidae)* in groundwaters of Germany, originated from the interstitial of the Danube catchment area

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The genus Moraria is represented by 69 taxa and mainly distributed in freshwaters of the Holarctic region. Species and subspecies of Moraria are epibenthic, semiterrestrial or dwelling in springs, caves or interstitial habitats. During a biomonitoring program of groundwaters of Germany, several species of harpacticoid copepods, belonging to the genera Bryocamptus, Moraria and Epactophanes richardi were collected. Within the 3 found species of Moraria, one could not be assigned to any known species of the genus and was considered as new. Moraria glitzae n. sp. was collected at interstitial waters of the Salzach River at the city of Burghausen in Bavaria.

Moraria glitzae n. sp. can be differentiated by a combination of morphological traits related to the shape of anal operculum, the chaetotaxy of leg 4 and the ornamentation of the urosome in both sexes. Males of M. glitzae present a typical number of armaments of the endopodites of legs 2 to 4, some of them with special morphology. Females can be differentiated by the number of segments of the antennula, the number of setae of the exopodite of antenna and the mandibular palp, chaetotaxy of leg 4, and size and chaetotaxy of leg 5. The relationship of the new species to the closer species M. catalana, M. jana, M. stankovitchi and M. varica was discussed. Morphological differences to other species inhabiting groundwaters and epigeic habitats of the region, viz. M. alpina, M. brevipes, M. fontinalis, M. mrazeki mrazeki, M. mrazeki macedonica, M. pectinata, M. poppei and M. radovnae were presented.

The description of the new species and a key for identification of the 20 species of Moraria, found in the western Paleartic region, was supplied at the published article:

Gaviria, S. & D. Defaye (2017). A new species of Moraria (Copepoda, Harpacticoida, Canthocamptidae) from groundwaters of Germany, including a key for the identification oft he species of the western Palearctic Region. Crustaceana 90 (13): 1537–1561.

The Austrian National Comittee ÖN of the IAD supported the presentation of these results at the 3rd International Conference on Copepods, held at L.A., California, USA in 2017.

Next IAD Conference

From July, 2–6 2018, the 42nd IAD conference will be organized in Smolenice, Slovakia

With the conference topic "Danube - a lifeline governed by multiple uses, pressures and a multitude of ecosystem services" the organizers put an emphasis on the intensified human impacts and the decreasing trends in goods and ecosystem services. Conference contributions will highlight ways to reverse or at least hold this adverse ecological and societal development and to improve sustainable development. Apart from scientific approaches and projects, the presentations will address the importance of international cooperation in research, monitoring and assessment as well as in management.

The conference offers key note lectures and sessions on topics such as ecosystem services and biodiversity, ecological status assessment, climate warming effects, perspectives for Danube sturgeons or the status of alien invasive species. Workshops related to the conference topic as well as a poster session will complete the scientific programme. On Friday, 6th July, an excursion will be offered to conference participants.

The 2018 conference of IAD will take place in the Congress Centre of the Slovak Academy of Sciences (SAS) situated in the well-known Smolenice Castle (www.kcsmolenice.sav.sk), the landmark of the Slovak town Smolenice. It is organized by the Institute of Geography of the Slovak Academy of Sciences, the IAD General Secretariat and the Slovak Limnological Society under the Patronage of the Vice President of Slovak Academy of Sciences, Dr. Pavol Siman.

For further details – including registration – please have a look at the conference webpage at http://conferences.ulbsibiu.ro/conf.iad/2018/index.php.

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Hydrological catchment of the River Danube

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