resistance situation in a large international river like the Danube, it is essential to understand the transfer mechanisms within the bacterial community. It is not only the presence or absence of resistance genes at the DNA level that must be investigated, but one also has to look for the reasons of the whereabouts and losses of resistance in the individual species. It is absolutely necessary to conduct these studies in parallel with isolates of different species in order to be able to identify the main influencing factors and to initiate countermeasures.

- As a basis for the understanding of sources, spread, accumulation and loss of antimicrobial resistance, reliable quantitative information must be available. So far, most studies provided only qualitative information on the presence or absence of ARB and ARG. Such quantitative data can also serve as a basis for the development of future guideline values demanded by health authorities.
- In order to develop effective management strategies, specifically the sources of antimicrobial resistances have to be identified. As input of ARB and ARG are most likely tightly linked to microbial fecal pollution, either of human (input primarily from municipal wastewater treatment plants) or animal origin (input primarily from agriculture and life-stock farming), the specific origin of fecal pollution has to be tracked with modern "microbial source tracking" tools.
- Moreover, only the comprehensive assessment of environmental conditions (the identification of sites where selection or co-selection for antimicrobial resistance may occur through e.g. heavy metals or pesticides) will enable a fundamental understanding of the mechanisms and importance of antimicrobial resistance in aquatic ecosystems.

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Danube countries review their options on flood risk management and include green infrastructures besides traditional measures in planning for a sustainable Danube

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Abstract

In compliance with the Flood Directive (FD) and Water Framework Directive (WFD), both the 1st Danube River Basin Management Plan (DRBMP) from 2009 (updated in 2015) and the 1st Flood Risk Management Plan for the Danube River Basin District (DFRMP) put forward ambitious targets for floodplain restoration, recognizing the multiple benefits for flood risk management, nutrient retention, water quality, biodiversity and the ecosystem and set out appropriate environment and flood risk management objectives covering the Danube Basin. Opportunities towards gaining synergies and key issues requiring coordination are clearly foreseen for the programmes of measures within the plans. Floodplain restoration and creation of new retention and detention capacities, in particular based on natural water retention, are likely to provide the most significant direct contribution to both Flood Directive and Water Framework Directive objectives but also to conservation objectives as contribution to Birds and Habitats Directive. (ICPDR, 2004)

By addressing the need to develop an action policy framework in relation to floodplain restoration in the Danube River Basin, the DANUBE FLOODPLAIN project is meant to provide tools and guidance to achieve long term solutions through floodplain restoration and conservation, decreasing the flood risk (discharge peaks) of the Danube River and selected tributaries. The project is expected to solve the challenge of implementing actions into restoration projects, to involve and to have the support of stakeholders (who are concerned about losing fishery, land and income) and to balance investments in flood risk management with other public infrastructural investments.

Introduction

Past and recent regularization works – dams and dikes, discontinuity of the longitudinal and lateral connectivity, changes in land use - that took place along the Danube basin, have led to a massive reduction of grassland surfaces. The reduction of these areas by up to 68% in the last 100 years has had disastrous effects on both - local communities that have been exposed to floods and on biodiversity. From 1980 to 2016, the total reported economic losses caused by weather and climate-related extremes in the European Economic Area (EEA) amounted to approximately EUR 436 billion (in 2016 Euro values) (EEA Annual Report, 2017). The Danube meadows have always played a role in natural protection against floods caused by rapid floods and overflows, so the decrease of their surface, along with the torrential rains caused by climate change, have entailed massive floods in Europe since 2002. At the same time, a further effect of the meadow reduction consists in the loss of habitats for many species, the loss of connections between ecosystems and implicitly the decline in biodiversity, a wealth of these areas in the past.

The Danube River Basin Management Plan (DRBMP) underlines that wetlands/floodplains and their connection to river water bodies play an important role in the functioning of aquatic ecosystems and have a positive effect on the water status. Connected wetlands/floodplains play a significant role when it comes to retention areas during flood events and may also have positive effects on the reduction of nutrients and the improvement of habitats. As an integral part of the river system they are hotspots of biodiversity, also providing habitats for e.g. fish and waterfowl that use such areas for spawning, nursery and feeding sites.

The 1st Danube River Basin Management Plan from 2009 concluded that compared to the 19th century, less than 19% of the former floodplain area has been preserved in the entire Danube River Basin (i.e. 7,845 km² out of once 41,605 km²). This was caused in particular by the expansion of agricultural uses and the disconnection from water bodies due to river engineering works concerning mainly flood control, navigation and hydropower generation. The disconnected wetlands/floodplains are potential pressures to aquatic ecosystems on the basin-wide level and the largest possible area with potential for reconnection should be restored in order to support the achievement of the environmental objectives (ICPDR, 2015).

Danube countries of basin-wide importance decided that more sustainable, nature-based solutions are needed to reduce the impact of floods

Being fully aware of this complex problem, the Danube countries, all of them members of the International Commission for the Protection of Danube River (ICPDR), decided to jointly develop a Danube River Basin project – DANUBE FLOODPLAIN Project – in order to analyze the potential flood-plain restoration areas, considering flood retention potential and other aspects such as ecological ones and biodiversity conservation, which should guide the future Programme of Measures (PoM) in the Danube River Basin.

The DANUBE FLOODPLAIN Project will contribute to (1) updating the disconected wetlands/floodplain areas inventory and their ranking using the Floodplain Evaluation Matrix – FEM, (2) assessing the efficiency of floodplain projects in the Danube District by using the pre-selected pilot areas and (3) developing tools for increasing the knowledge and cooperation of experts, practitioners, decision makers and stakeholders on floodplain restoration.

The project partnership consists of different levels e.g. policy makers, water managers, researchers, as well as stakeholders of water and flood risk management from the DRB who are involved in a permanent cooperation and interaction to develop the project. By involving policy makers and national water competent authorities the project ensures that possible floodplain restoration and preservation approaches for managing the risks of floods and reaching environmental and conservation objectives will be implemented in the future transnational water management activities. The most relevant stakeholders involved in floodplain management will not only contribute to the project outputs. The main project target groups are ministries, river basin authorities, practitioners and stakeholders (AF, 2018).

The partnership is represented by institutions from ten countries of the Danube River Basin from upstream to mid-

dle and downstream, nine EU members and one accession state (Serbia). The active implication of the ICPDR and its relevant technical expert groups during the project implementation process will ensure that the project results are transposed into further actions within the whole Danube River Basin.

Identifying floodplain areas and interventions along the Danube River and its tributaries which will integrate the most beneficial ecological and flood protection advantages.

In figure 1 the main project activities are presented grouped in three main chapters relating to

- (1) the Danube floodplain evaluation,
- (2) selected pilot areas of the Danube Floodplain project and
- (3) the outputs of the project.

(1) The innovative character of the DANUBE FLOODPLAIN project is given by the application of the Floodplain Evaluation Matrix (FEM) by all partner countries and by developing a general evaluation tool for potential further assessment of floodplain restoration projects. The Floodplain Evaluation Matrix (FEM) is a multicriteria holistic and integrative decision support system that helps to determine which floodplains are highly relevant for preservation and/or restoration

concerning not only flood protection (hydrology/hydraulics) but also ecological and socio-economic reasons. The FEM approach will be supported by a stakeholder ranking, which results in a priority list and proposal of potential preservation and restoration sites considering flood and ecological aspects and stakeholders interests.

During the first phase of implementation, FEM will be applied to active floodplains. Active floodplain was defined based on simultaneous compliance of the following conditions:

- the ratio between the width of the floodable area (Li) and the riverbed width (La) is greater-than-unity (Li / La > 1)
- floodable area surface is larger than 500 ha.

According to FEM, determination of the hydraulic efficiency presumes to assess the water stage corresponding to 100 Qmax (maximum flow rate of 1 % annual probability of exceedance) derived within the following assumptions regarding the streamflow section:

- streamflow section is delimited vertically at the line representing the banks level H1,
- streamflow section corresponds to the current development situation H2,
- streamflow section corresponds to the flood defence works (dikes) relocating scenarios



Figure 1. General illustration of the activities in the Danube Floodplain project and their interdependencies. Source: TU Munich, Johannes Mitterer.

The project partners will review and update active and former floodplain areas (including data collection and analyses of these data using GIS), with the aim to provide a spatial reference framework alongside the related database containing a comprehensive inventory of floodplain areas and their multicriteria analysis along the Danube River and selected tributaries. The resulting theoretical and actual floodplain areas inventory will provide the main spatial reference base, where other hydrological, hydraulic and biophysical parameters will be analyzed. The geodatabase will also be accompanied by a list of associated existing measures identified from national and international Flood Risk Management Plans and River Basin Management Plans, which have the integrative positive effect on both – flood protection and ecological improvement.

(2) The other major part of the project is the assessment of the efficiency of preservation and restoration projects for flood risk reduction and improvement of ecosystem services on the Danube and its major tributaries using pre-selected pilot areas in the Danube basin. A comprehensive analysis, assessments of different measures concerning flood risk reduction in pre-selected pilot areas (including qualitative and quantitative impact on biodiversity, habitat networks and ecological system services), costs and benefits and governmental procedures are executed in the project.

Ecosystem Services (ESS) and a comprehensive analysis of biodiversity are done in the pilot areas in order to quantify the potential positive effects of the measures and to integrate, as far as possible, these projects into the overall biodiversity concept of the Danube.



Figure 2. Stakeholder Workshop on ecosystem services (ESS) in Port Cetate, Romania, 2019. Photo: Anemari Ciurea

It is important to distinguish between the current ESS, on which many detected stakeholders have already been relying, and the potential ones. Therefore, the project partners organize workshops where project partners and stakeholders meet to discuss the prevailing ESS. The experiences



Figure 3. Pre-selected pilot areas for the assessement of the efficiency of preservation and restoration projects. Source: TU Munich, Johanna Springer.

Figure 4. Danube Floodplain project outputs and deliverables

gained from other projects, like River Ecosystem Service Index (RESI; BMBF, Germany) constitute the basis for the assessment of ESS.

The selected pilot areas are Krka in Slovenia, Begečka Jama in Serbia, Morava on the border between Slovakia and the Czech Republic, Middle Tisza in Hungary and Bistret in Romania.

(3) The main outputs of the project are shown in the Figure 4.

The objective of the project is to increase the knowledge and cooperation of experts, practitioners, decision makers and stakeholders on floodplain restoration especially for the purpose of flood risk mitigation and agreed next steps towards achieving such projects.

In order to accomplish the above mentioned different target groups, the project produces three types of helping tools:

Danube Basin Wide Floodplain Restoration and Preservation Manual: mainly addressed to practitioners; it explains technical details of the key restoration approaches, potential win-win measures to mitigate flood risk through floodplain restoration and conservation actions; furthermore, it contains a step by step explanation on how to plan and implement restoration projects, how to solve potential conflicts in an integrated way involving all related stakeholders.

Danube River Basin Sustainable Floodplain Management Strategic Guidance, summarizing the key findings of the Manual but targeting a wider audience.

Danube River Basin Roadmap, which will use the results of the ranking process and the thorough analysis of pilot areas, providing an action plan on how to move forward in order to realize further multipurpose restoration projects after the end of the project. These necessary actions, agreed deadlines on a Danube wide level, and responsibilities will be defined on Danube basin and national levels. Decision makers and planners are the target groups of the DRB Floodplain restoration Roadmap which will directly serve as an input for developing the 3rd Danube River Basin Management Plan and the 2nd Danube Flood Risk Management Plan and to support national planning as well.

All the information included in these output documents will support the implementation of the Water Framework Directive, the Flood Directive and biodiversity strategy within the Danube basin countries.

Conclusions

The main results of the project will be an improved and sustainable transnational flood risk mitigation management within the Danube River Basin. The concrete measures identified in the frame of the project pilot areas, alongside the measures related to priority areas. will contribute to increase potential capacities in natural flood retention, to improving retention and flood protection downstream from pilot and future restoration sites and to advancing the Danube Flood Risk Management Plan and Danube River Basin Management programme of measures. Furthermore, the project results will contribute to a harmonized approach for dealing with floodplain conservation and restoration measures, to a consensus of local stakeholders on priority measures and to a wider public support for integrating flood management with floodplain conservation and restoration.

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