Impact of large-river restoration measures on the taxonomic and functional composition of the macroinvertebrate community (Danube, Austria)

Impact des mesures de restauration des grands cours d'eau sur la composition taxonomique et fonctionnelle de la communauté de macroinvertébrés (Danube, Autriche)

[1,2]Funk Andrea, [1,2]Bondar-Kunze Elisabeth, [2]Recinos Brizuela Sonia S., [1,2]Hein Thomas

[1]Christian Doppler Laboratory for Meta Ecosystem Dynamics in Riverine Landscapes, Institute of Hydrobiology and Aquatic Ecosystem Management, Department of Water, Atmosphere and Environment, BOKU University, Vienna, Austria, Vienna
[2]Institute of Hydrobiology and Aquatic Ecosystem Management, Department of Water, Atmosphere and Environment, BOKU University, Vienna, Austria

RÉSUMÉ

La restauration des grandes rivières de plaine inondable est une tâche importante mais difficile, car elles présentent une biodiversité exceptionnellement élevée, mais sont également contraintes par de multiples utilisations humaines. Nous présentons les résultats d'un projet pilote de restauration innovant, le « Projet pilote Bad Deutsch-Altenburg », mené sur l'un des derniers tronçons à écoulement libre du Danube près de Vienne en Autriche, où les efforts de restauration sont évalués sur la base de la composition taxonomique et fonctionnelle de la communauté de macroinvertébrés. Différentes mesures de restauration, à savoir la reconnexion d'un ancien canal latéral isolé, la création d'un canal secondaire, l'adaptation du champ d'épis et la renaturalisation des berges, c'est-à-dire l'enlèvement des enrochements le long des berges, ont été mises en œuvre et leurs résultats ont été évalués dans le cadre d'un programme de surveillance à court et à long terme. Les premiers résultats montrent que la reconnexion ouverte du canal de la plaine d'inondation a conduit à un changement clair de la communauté de macroinvertébrés vers une communauté rhéotopique typique basée sur le pâturage, tandis que la renaturalisation des berges et d'autres mesures en cours d'eau ont eu un impact indirect sur la disponibilité de la zone d'habitat de cette communauté ciblée typique.

ABSTRACT

Restoration of large floodplain rivers is an important but challenging task, as they have an exceptional high biodiversity but are also constraint by multiple human uses. We present the results of an innovative restoration pilot project “Pilot Project Bad Deutsch-Altenburg” conducted at one of the last free-flowing sections of the River Danube close to Vienna in Austria, where restoration efforts are evaluated based on the taxonomical and functional composition of the macroinvertebrate community. Different restoration measures, i.e., reconnection of a former isolated side-channel, creation of a secondary channel, groyne-field adaptation and bank re-naturalization, i.e., removal of riprap along the banks, were implemented and outcome evaluated in a short and long-term monitoring program. First results show that the open reconnection of the floodplain channel has led to a clear shift in the macroinvertebrate community towards a typical rheotopic grazer-based community whereas bank re-naturalization and other instream measures had an indirect impact on the availability of habitat area of this typical targeted community.

KEYWORDS

Floodplain reconnection, bank re-naturalization, rheotopic, long-term monitoring, species traits

Reconnexion des plaines inondables, renaturalisation des berges, rhéotopique, surveillance à long terme, caractéristiques des espèces

1 EXTENDED ABSTRACT

1.1 Introduction

Large rivers are among the most biodiverse but also most threatened ecosystems worldwide. Starting in the 19th century, rivers have been modified for human demands including energy production, flood protection and transportation. This led to a strong decline of many native species, driven by the loss and alteration of habitat and connectivity between habitats including main stem and floodplain habitats. This also led to reduced functioning of the system and consequently loss of ecosystem services provided (Tockner & Stanford 2002).

Consequently, during the 90s restoration of river habitats and the reconnection of isolated floodplains became a critical component to restore and conserve the threatened communities (Schiemer et al. 1999). Due to severe constraints related to the multiple human uses, the restoration of large floodplain river is a specifically complex task. Restoration measures for large rivers including re-naturalization or creation of secondary habitat along riverbanks and shallow zones of the main stem as well as reconnection of isolated floodplains and the riparian area, which must be reconciled with the usability of the system for human uses such as navigation or flood control (Pess et al. 2005).

In a pilot study, the "Pilot Project Bad Deutsch-Altenburg", along the Danube close to Vienna within the borders of the nationalpark "Nationalpark Donau-Auen", several restoration and combined engineering and restoration measures have been implemented, include re-naturalization of river banks by removing hard structures i.e., riprap along the shoreline, creation of a secondary flow channel, the reconnection of an isolated floodplain channel or the modification of groyne-fields, balancing requirements for navigation and ecology (Ramler & Keckeis 2019).

We use data on the macroinvertebrate community from an intensive monitoring program including pre-monitoring and post-monitoring in three phases ranging from directly after up to 10 years after the restoration to evaluate the different measures. Impact on the community composition, targeted rheotopic community as well as shift in functional groups is analyzed using statistical as well as GIS based analysis.

1.2 Methods

The Danube close to Vienna is a ninth order former braided gravel-bed river with a mean discharge of 1910 m^3/s with a high stochasticity in flow and floods can occur throughout the whole year. It is one of the last remaining free-flowing stretches of the Upper Danube. The pilot study "Pilot Project Bad Deutsch-Altenburg" is part of the large scale hydro-engineering and restoration concept for the nationalpark area the " Integrated River Engineering Project (IREP) " which was implemented to test multiple restoration and engineering measures as basis for the implementation and adaptation of measures in the remaining project areas (Ramler & Keckeis 2019).

1.2.1 Measures tested

Following measures were tested in the pilot project (Ramler & Keckeis 2019):

- Bank re-naturalization was tested along an approx. 1km long stretch where riprap was removed along the banks to allow natural erosion and sedimentation pattern.
- Creation of a secondary flow channel combined with the modification of a groyn-field along an approx. 0.5 km section
- Open reconnection of an isolated side-channel with an approx. length of 1.5 km.

1.2.2 Monitoring and data analysis

At every sampling event, one pre-monitoring and three phases of post-monitoring, 25 samples were taken with a Hess-sampler (mesh size 200 µm, area per sample = 0.102 m^2) along the shoreline. In the side-channel additionally FreezeCore samples were taken to analyze the impact of the reconnection on the depth distribution of the macroinvertebrate community. Species were determined to the highest possible taxonomic level (preferably species) by local experts. We follow a common BACI (Before-After-Control-Impact) design, a control site not impacted by the restoration measures and the restoration sites were sampled equally before and in the three phases after the restoration. For the statistical analysis therefore a two-way ANOVA design was selected to conclude on the changes in the community that can be accounted to the restoration measures, controlling for other confounding factors such as differences in hydrological conditions between the years. Additionally, a hydrodynamic model (Glock et al. 2019) available for the pre- as well as post-monitoring phases allowed us to

model the changes in the availability of different zones and their relevance for the macroinvertebrate community. Change in the functioning was evaluated based on functional species traits such as feeding groups and habitat preference traits.

1.3 Preliminary results

The final post-monitoring phase is still ongoing, but the first two phases already led to clear results regarding the restoration impact. The strongest direct effect was induced by the reconnection of the side-channel system, already in the first post-monitoring phase community composition and functional composition shifted towards a typical rheotopic grazer-based community. Additionally, a strong increase in the colonization of deeper sediment zones of the side-channel (up to 1m depth) was detected. The overall community became significantly more similar to the main stem. In contrast, the restoration measures along the banks did not lead to a direct change in the community, despite the areas that were directly impacted by the riprap which hosts a different community. However, the GIS analysis based on the hydrodynamic model revealed that the availability of habitat area available for the different functional communities shifted significantly due to the restoration measures. The data from the last monitoring phase, which will soon be completed, will provide new additional insights for the study.

LIST OF REFERENCES *(only for scientific papers)*

Glock, K., Tritthart, M., Gmeiner, P., Pessenlehner, S., & Habersack, H. (2019). Evaluation of engineering measures on the Danube based on numerical analysis. Journal of Applied Water Engineering and Research, 7(1), 48-66.

Pess, G. R., Morley, S. A., Hall, J. L., & Timm, R. K. (2005). Monitoring floodplain restoration. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland, 127-166.

Ramler, D., & Keckeis, H. (2019). Effects of large-river restoration measures on ecological fish guilds and focal species of conservation in a large European river (Danube, Austria). *Science of the total environment*, *686*, 1076-1089.

Schiemer, F., Baumgartner, C., & Tockner, K. (1999). Restoration of floodplain rivers: The 'Danube restoration project'. River Research and Applications, 15(1-3), 231-244.

Tockner, K., & Stanford, J. A. (2002). Riverine flood plains: present state and future trends. Environmental conservation, 29(3), 308-330.