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Restoring fluvial landscapes – ecological effects of side-arm reconnection

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Abstract

River regulation works altered key ecosystem properties. An analysis of various restoration measures along the Upper Danube River to mitigate some of these alterations shows the effects of different reconnection measures on key ecosystem functions such as nutrient retention and plankton communities in different side arm and floodplain systems. Aspects analysed are to what extent pre-regulation conditions can be achieved, what critical constraints have been identified and what are the long-term perspectives of these measures to achieve an overall improvement of ecological conditions.

Keywords

hydrological connectivity, plankton, nutrients

Introduction

Aquatic and terrestrial parts of floodplains are key elements of riverine landscapes and are important areas for biodiversity, ecosystem functions and a multitude of services by for example controlling the regional water cycle and the retention of nutrients (Hein et al. 2016, Rebelo et al. 2013, Schindler et al. 2014, Weigelhofer et al. 2015). Lateral hydrological connectivity, defined as the water exchange between floodplain water bodies and the river channel, is the key determinant of water related ecosystem processes such as nutrient turnover, sediment and water related processes (Hein et al. 2004, Welti et al. 2012).

While there is a wide appreciation of ecosystem services provided by riverine landscapes, there have been dramatic losses of area and reduction of the ecological functionality in remaining areas due to land reclamation and channel engineering in the past (Hohensinner et al. 2008). This resulted in an ecological degradation and in a reduced provision of several ecosystem services worldwide (Tockner et al. 2010). Thus, many remaining areas have been protected and to improve overall conditions restoration schemes have been implemented. As part of these activities, hydromorphological measures as one option have been designed and partly implemented to improve the hydrological connectivity of main channel habitats and floodplain water bodies in the Danube River (Hein et al. 2016).

In order to quantify the ecological effects of hydromorphological restoration measures, we investigated several side arm restoration measures in the Danube Floodplain Nationalpark in the Austrian Danube. The aim was to analyse how the extent of side-arm restoration (the days of hydrological connectivity per year) control nutrient retention and planktonic processes in the water column of different side-arm systems. We expected that nutrient concentration follow closely the extent of connectivity, while plankton compartments show responses that are more complex.

Study site description and study design

The investigation area with several side-arm restoration projects was situated in the river floodplain stretch between Vienna and the Slovakian border (Reckendorfer et al. 2005). In each side arm at one station, located in the middle of the side am, was sampled during water level conditions below mean water in 2014 and 2015 (Fig. 1). For the statistical analyses, 8 sampling dates per parameter and site were used. The parameters investigated were inorganic nutrients and different components of the plankton community. Methods followed detailed descriptions in Hein et al. 2004 and Baranyi et al. 2002.

Results and Discussion

The comparison showed that phosphate concentrations in the water column during low water levels were significant lower in the side arm Regelsbrunn (lowest connectivity levels) compared to all other systems (Fig. 2). Notable in that respect was the low mean concentration in the Orth system, but high variability at the same time. In the Johler Arm the range of concentration was at the same level as in the Danube main channel. This points to the fact that at medium levels of restored hydrological connectivity a significant nutrient retention can still be observed. At levels of a permanent reconnection, the nutrient status of the side-arm is the same as in the Danube.

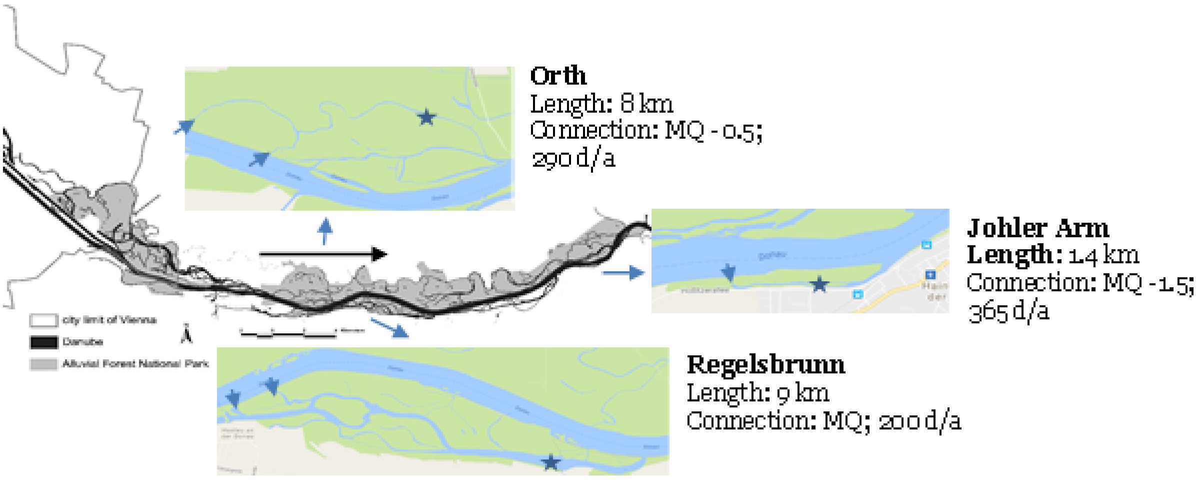

Figure 1: Map of investigation area, inserts investigated side arms. Stars mark sampling sites, arrows inflow areas. MQ: mean discharge in the river, connection: level at which side arm system is connected upstreams with the river main channel

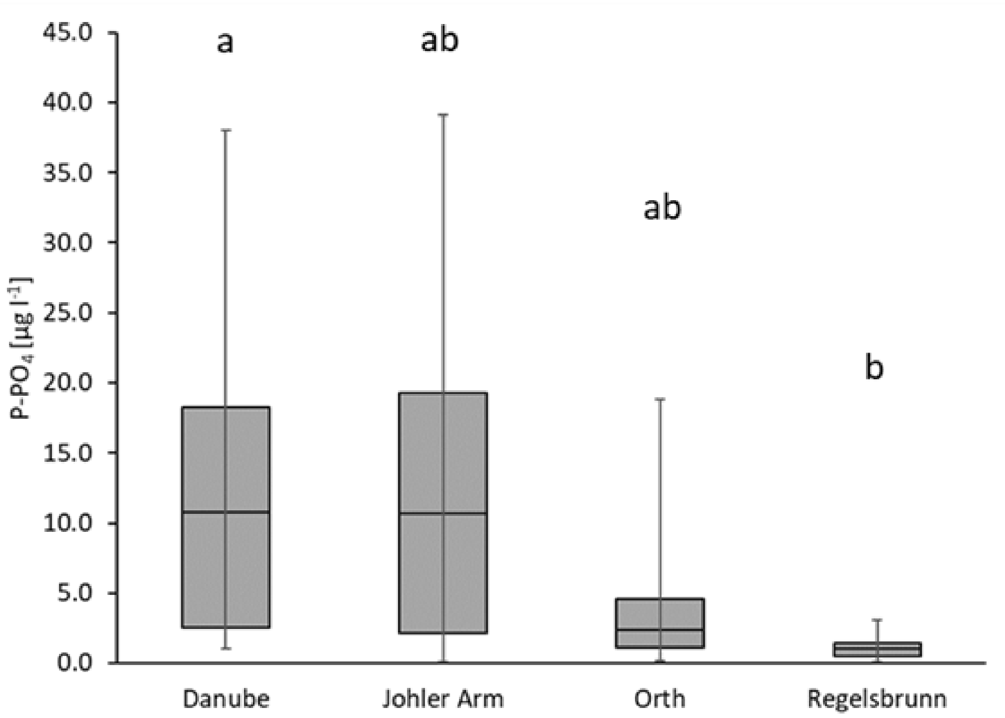

Figure 2: Boxplot of P-PO4 concentration in the water column; N = 8. Significance tested by Kruskal-Wallis one-way ANOVA = 0.027, letters indicate significant difference.

For plankton compartments, the following patterns were observed: Chlorophyll-a (Chla) as surrogate for phytoplankton biomass showed no distinct differences between river main channel and the restored side-arms, with mean Chla concentrations between 7 and 12 µg l^{-1} indicating medium productivity levels in these systems. Zooplankton abundance was low in the Danube, Johler Arm and Orth, while Regelsbrunn showed significant higher abundances (Fig. 3). Here the phases of disconnection are sufficient to increase retention times and allow a significant zooplankton development. The main groups have been rotifers and crustaceans (BARANYI et al. 2002). These differences in phytoplankton and zooplankton pattern point to a complex interaction of controlling factors, where highly connected systems are primarily controlled by abiotic factors, while medium connected systems show certain periods of dominant biotic control.

These results highlight that we do not observe gradual changes related to the amount of hydrological connectivity restored, rather than threshold responses, even for plankton communities. The same evidence can be provided for nutrient retention as an important ecosystem service showing comparable patterns, with still measurable nutrient uptake at medium connectivity levels. Thus, for the design of future restoration measures these findings can be applied to define realistic aims such as improved ecosystem services, or approaching riverine conditions for aquatic communities. Our results suggest that at medium connectivity levels nutrient retention can be optimized as frequent riverine pulses can be efficiently taken up by side arm communities, while permanent connectivity and lotic conditions lead to a dominant hydrological control of plankton communities.

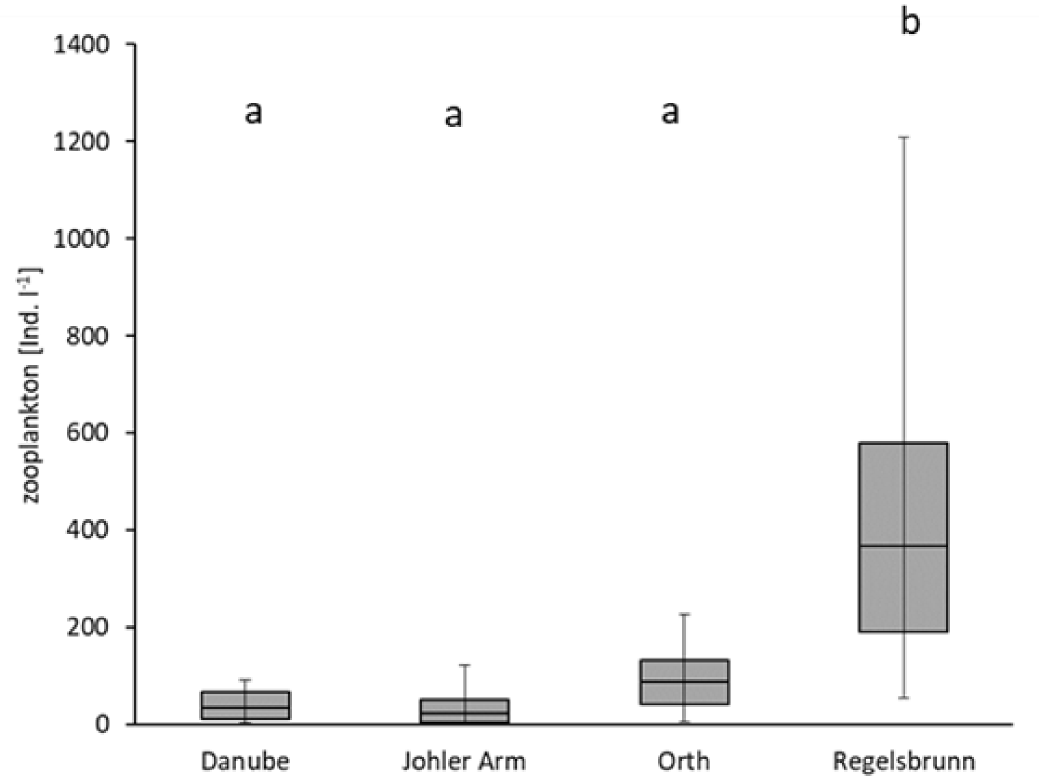

Figure 3: Boxplot of zooplankton abundance; N = 8. Significance tested by Kruskal-Wallis one-way ANOVA = 0.012, letters indicate significant difference.

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