Water enhancement scheme Lobau – a conservation strategy for an urban floodplain in Vienna (Austria)

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Introduction

Riparian zones, floodplains and river–marginal wetlands are among the most endangered freshwater ecosystems worldwide nowadays (Brinson & Malvarez 2002, Malmqvist & Rundle 2002). Most wetlands within urban regions have already been converted to terrestrial ecosystems, settlements, industrial areas or agricultural land (Faulkner 2004, Groffman et al. 2003). The remaining floodplains often show a high degree of degradation (Tockner & Stanford 2002). River regulations in the course of flood protection measures as well as large scale land-use changes have altered the hydrological regime and, thus, reduced the ecological integrity of these ecosystems drastically. As a consequence, urban floodplains are usually far from a even near natural state, lacking most of their basic ecological functions as important ecotones between the adjacent aquatic and terrestrial ecosystems (Bujise et al. 2002). Therefore, strategies to conserve or restore such environments have to be designed, and their ecological success has to be measured.

We present a water enhancement scheme for the Lobau, a 2,300 ha large former floodplain of the River Danube within the eastern border of the City of Vienna. The construction of a flood protection dam along the river banks in the course of the regulation of the Danube in 1875 led to heavy modifications of the hydrological exchange between the floodplain and the river, thereby changing associated floodplain processes. Before the realisation of the water enhancement scheme, the Lobau represented a mainly groundwater-fed and back-flooded floodplain system where the main channel consisted of several partly disconnected and often highly eutrophic basins of standing waters. Despite the high degree of degradation, the Lobau still harbours a diverse mosaic of aquatic, semi-aquatic and terrestrial habitats. Due to its high ecological value, the Lobau is classified as a wetland of international importance according to the Ramsar Convention and is part of the Alluvial Zone National Park. However, the reduced hydrological connectivity with the Danube, together with prevailing sedimentation and eutrophication processes, result in a gradually decline of the groundwater levels and in a decrease of aquatic habitats, endangering the still high diversity of the floodplain. Furthermore, the Lobau plays a central role in the landscape water balance and is target of several socio-economic demands, such as flood protection, drinking water supply or recreation. Some of these social requirements are in conflict with nature protection objectives and may restrict the alternatives of restoration measures.

On behalf of the City of Vienna, a controlled water enhancement scheme for the Lobau was proposed in 1990 which comprised the re-connection of the floodplain at the upstream site of the main channel via controlled surface water input from an artificial side-arm of the Danube. The aim of the project was to restore the surface connection along the main channel, ensure

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the enrichment of groundwater within the floodplain, sustain the present diverse mosaic of aquatic and semi-aquatic habitats and increase the nutrient output of the eutrophic backwater system (IMHOF *et al*., 1992, Bondar et al. in press).

Due to the different local potential for renaturation and the various socio-economic demands within the upper and lower part of the Lobau, the project was divided into two phases. Phase I concentrated on an enhancement scheme for the Upper Lobau. After a four years test phase lasting from 2001 to 2004, the regulated water supply for the Upper Lobau was officially notified with a licence for a maximum water input from the Danube of 1.5 m^3s^{-1} between March and November. The quantity of the actual input depends on the quality of the river water and is restricted by hydrological, hygienic and trophic thresholds (amongst others surface and groundwater levels in the floodplain, and concentrations of *Escherichia coli*, P_{tot} and chlorophyll a in the water source). The effects of the water enhancement scheme on the metabolism and the biota of the affected water bodies are controlled every year via a hydrological and limnological monitoring program.

Phase II includes the expansion of the water enhancement scheme to the Lower Lobau with the aim to re-connect it with the Upper Lobau via surface water pathways, and to establish a downstream water exchange through the entire floodplain. As in Phase I, the focus lies on the conservation of the present state and the protection of the existing rare limnophilic species. Additionally, the immigration of rheophilic species should be enhanced by introducing variable flow conditions within the main side arm. Phase II is currently in preparation. In this paper we demonstrate, that a controlled water input of even low quantities of river water is able to stabilize the groundwater levels and increases the nutrient output of this backwater system.

Methods

The experimental phase of the water enhancement scheme “Dotation Lobau” started in spring 2001 and lasted until the end of the year 2004. For the analyses of the long-term development of the area, water quality surveys were done in monthly intervals during the vegetation period from 1996 to 2004, covering a wide range of geochemical and trophic parameters (Bondar et al. in press; Hein et al. 2001). In addition, water levels were recorded in the surface water along the main channel as well as in the groundwater. The survey was accompanied by experiments as to geochemical and biological processes in the floodplain (e.g. primary production patterns; Bondar et al. in press). Furthermore, the long-term effects on the biota were analysed.

Results and Discussion

Short term effects of the experimental phase in the Upper Lobau

Due to the limitations with respect to surface and groundwater levels, the mean discharge was between 200 and 250 ls^{-1} during the experimental phase, with peaks of up to 400 ls^{-1}. Despite the relatively low amounts of water input, the management measures led to a water enhancement across the whole Upper Lobau, which affected groundwater as well as surface water levels. Maximum water levels remained the same, but the frequency distribution was shifted to higher medium water levels. The overall increase of mean surface water levels was approximately 0.5 m.

Within the re-connected basins along the main channel, the water enhancement scheme resulted in a significant decrease of the water residence time. The cumulative residence time for the 12 km long main channel decreased from over 800 days during the groundwater fed phase prior to the management measures to less than 35 days during the phase of surface water input. The retention time exponentially declined with increasing discharge from the

river (Fig. 1). The surface re-connection of the basins along the main channel led to a unification of the water quality. Variability in geochemical and trophic parameters decreased in space and time (Fig.2). While disconnected backwaters show varying levels of conductivity from 400 µScm^{-1} up to 750 µScm^{-1}, depending on the chemistry of the adjacent groundwater, connected water bodies are characterized by equally low values of about 450 µScm^{-1}due to the influence of the Danube water.

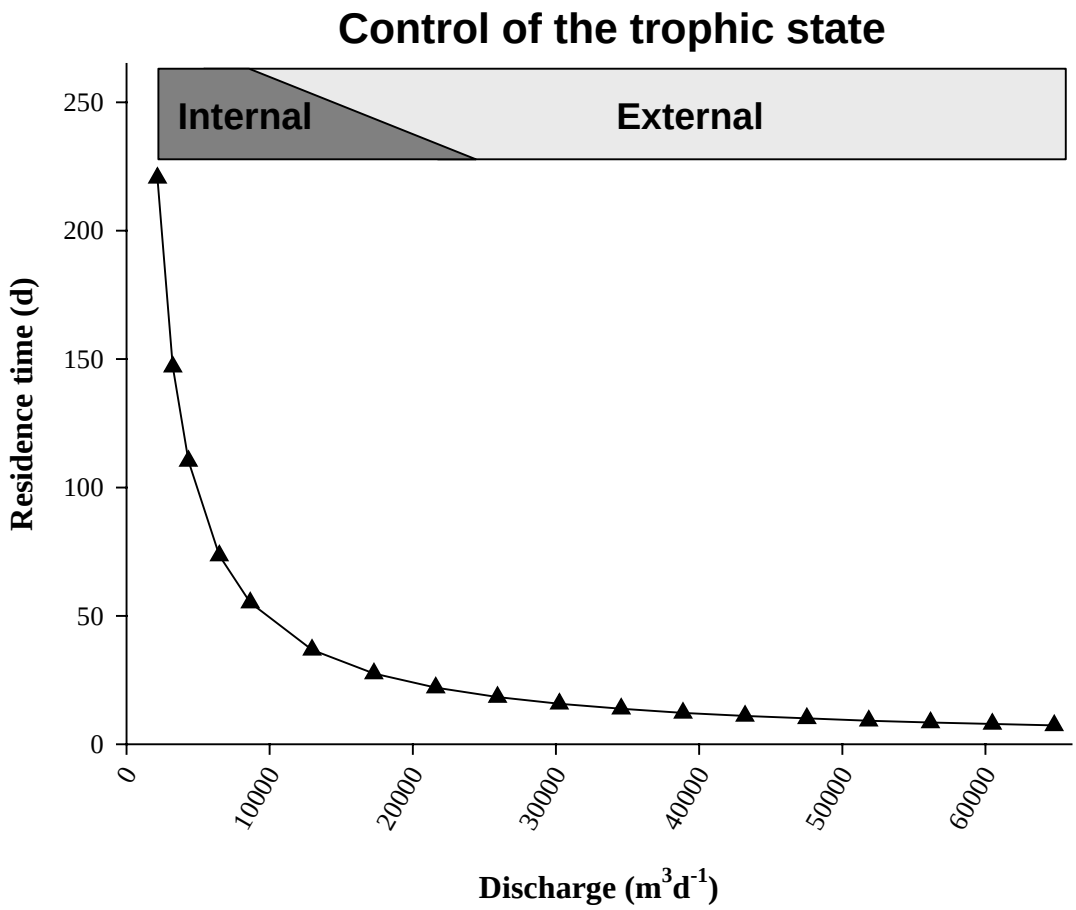

Fig. 1: Theoretical residence time in the affected water bodies in relation to different discharges; the horizontal bar indicates the gradual transition from a predominantly internal control of the trophic state in the water bodies to a predominantly external control.

The lower trophic level of the discharged river water also provoked an overall decrease in the trophic state of the system. Due to high accumulations of organic matter in the sediments and release of phosphor, groundwater-fed backwaters in the Lobau usually posses a high potential for eutrophication. Local inputs in the course of societal utilizations (e.g. swimming, deposal of litter, etc.) and via the groundwater deteriorate the situation. The Panozzalacke, for example, a disconnected groundwater-fed basin, shows P_{tot} concentrations of up to 50 µgl^{-1} in summer (Fig. 2).

Similar high values can be found within single basins along the main channel during phases of disconnection (e.g. in early spring). However, in the course of the surface water exchange, the trophic level of the basins along the water path gradually reaches the values of the mesotrophic water source, showing a decrease in total phosphorous down to 20 µgl^{-1} (Fig. 2). The efficiency of the management strategies depends on water residence time and, thus, is influenced by the magnitude of the discharge. The system remains predominantly internally controlled until a discharge rate of about 8000 m^3 and a water residence time of more than 50

days. This situation is characterised by community interactions (e.g. zooplankton grazing, algae – macrophyte competition), seasonal patterns and geochemical processes (Bondar et al. in press; Fig. 1)

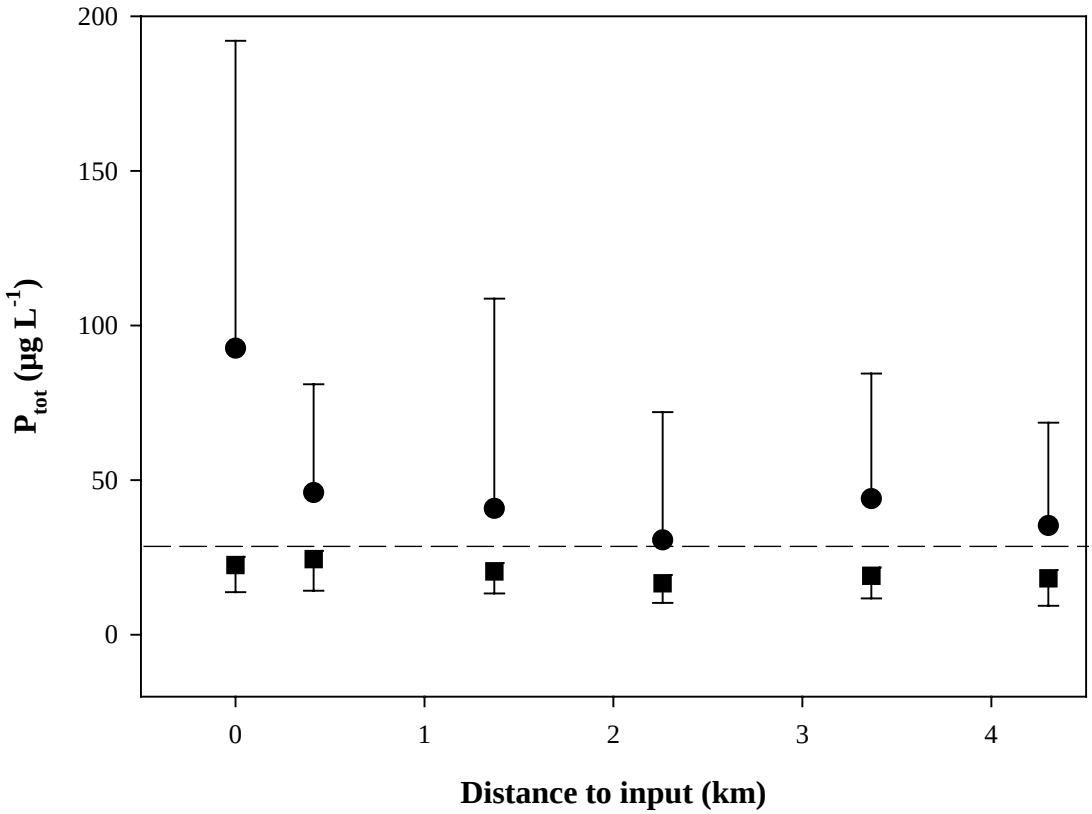

Fig.2: Total phosphorus concentrations (P_{tot}) with standard deviations in the Upper Lobau (Mühlwasser – the main channel of the floodplain) versus the distance from the water input. Black full circles: Mean P_{tot} concentrations in years prior to the enhancement scheme (1995-1999). Black full squares: Mean P_{tot} concentrations during the input of river water in the experimental phase (2001-2004). The dotted line indicates the mean P_{tot} concentration of the water source.

A regular input of more than 8000 m^3 per day, however, causes the system to shift gradually to a more hydrologically controlled one, in which the trophic state depends mainly on the quantity and the quality of the discharged river water. At this state, seasonal patterns of algal growth are overlain by exchange rate patterns (Bondar et al. in press).

While the enhancement scheme in the Upper Lobau resulted in a unification of the quality of the water body, at the same time it brought about an increase in the heterogeneity of the hydrological features, by introducing local current patterns. Water velocities increased up to 0.5 ms^{-1} within narrow subsections (weirs or outlets)of the main channel, thus raising the habitat diversity by providing small sections with flowing conditions for the colonization of rheophilic stream biota (e.g. molluscs, Funk et al. 2005)

Long term effects of the experimental phase in the Upper Lobau

Faunistic analyses prior to the enhancement scheme and at the end of the experimental phase revealed an increase in species numbers for dragon flies and molluscs (Funk et al. 2005). Species mainly reacted to the overall water enhancement within the project area by using disconnected water bodies for colonisation. Along the main channel, an immigration of rare

mussels (*Anodonta cygnea*, *A. anatina* and *Unio pictorum*) could be observed within local sections of flowing water conditions. Until now, the fish community showed no response to the water enhancement scheme.

Conclusions

The water enhancement scheme Lobau demonstrates that a controlled water input of even low quantities of river water is able to stabilize the groundwater levels and increases the nutrient output of this backwater system. The efficiency of this measure depends on the water residence time, which is controlled by the magnitude of discharge, and on the quality of the river water source. Above a certain discharge, the system gradually shifts from an internal control to an external control of the trophic state of the affected water bodies.

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