Variable enzymatic activity of prokaryotes under different hydrological settings in a river floodplain system of the Danube

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Introduction

River-floodplain systems play a significant role in organic matter cycling and carbon mineralization, sequestration and transport (Battin et al. 2008). In floodplains, the driving force of lateral exchange processes is hydrological connectivity, both via surface flow and via groundwater inflow (Tockner et al. 1999). A previous study revealed that hydrological connectivity between the main channel and a floodplain segment influenced productivity of both free-living (FL) and particle-associated bacteria (PA) (Luef et al. 2007). There is also evidence that hydrological retention can influence hydrolytic extracellular enzymatic activity (EEA) in floodplain sediments (Burns and Ryder, 2001), however the activity of oxidative enzymes may show no relation to hydrology (Williams, 2000). The extent to which FL and PA enzymes contribute to overall activity may be highly variable as a result of biological and physical processes, such as variable hydrological connectivity. However the question if variable hydrology, especially frequency of connection is mirrored in enzymatic activity in river floodplain systems remains largerly unknown.

Hyphothesis

Degree of connectivity and water exchange in floodplain lakes influences prokaryotic enzymatic activity both free-living (FL) and particle-associated (PA).

Results and discussion

Enzymatic acctivity in ambient water (FL) under different hydrological connectivity

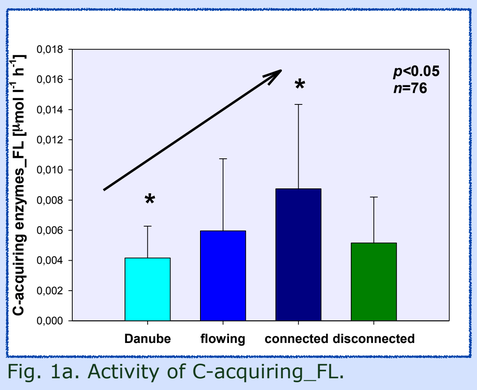


Fig. 1a. Activity of C-acquiring_FL.

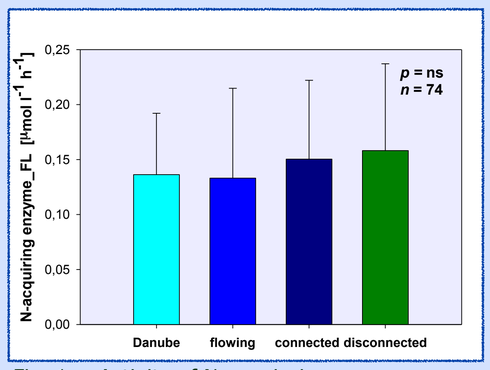


Fig. 1 c. Activity of N-acquirnig enzyme

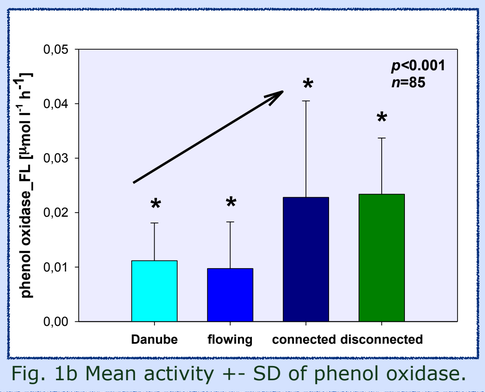


Fig. 1b Mean activity +- SD of phenol oxidase.

- Activity of C-acquiring enzymes and phOx in ambient water (FL) increased together with decreasing connectivity (Fig.1a,b).
- N-acquiring enzymes did not show clear dependencies on the degree of connectivity (Fig. 1c).

Means ± SD of 12 plants are shown.

Enzymatic acctivity associated with particles (PA) under different hydrological connectivity

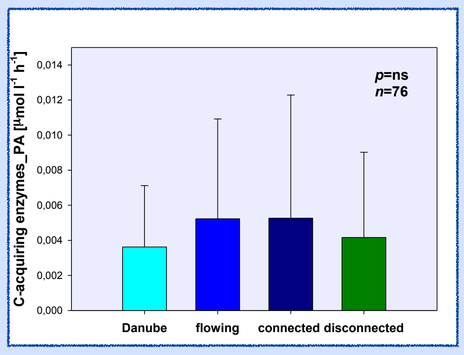


Fig. 2a

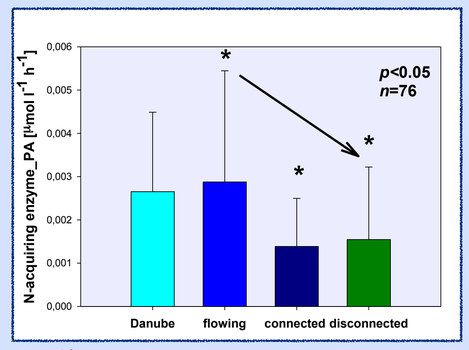


Fig. 2b

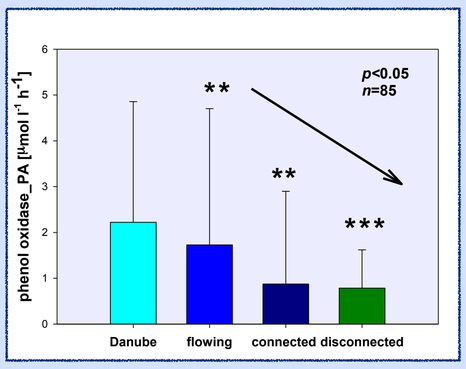


Fig. 2c

- Along with a gradient of connectivity, no significant changes in activity of C-acquiring_PA enzymes was observed (Fig.2a).
- Activity of N-acquiring enzyme and phenol oxidase associated with particles (PA) decreased with the degree of connectivity (Fig.2b,c).

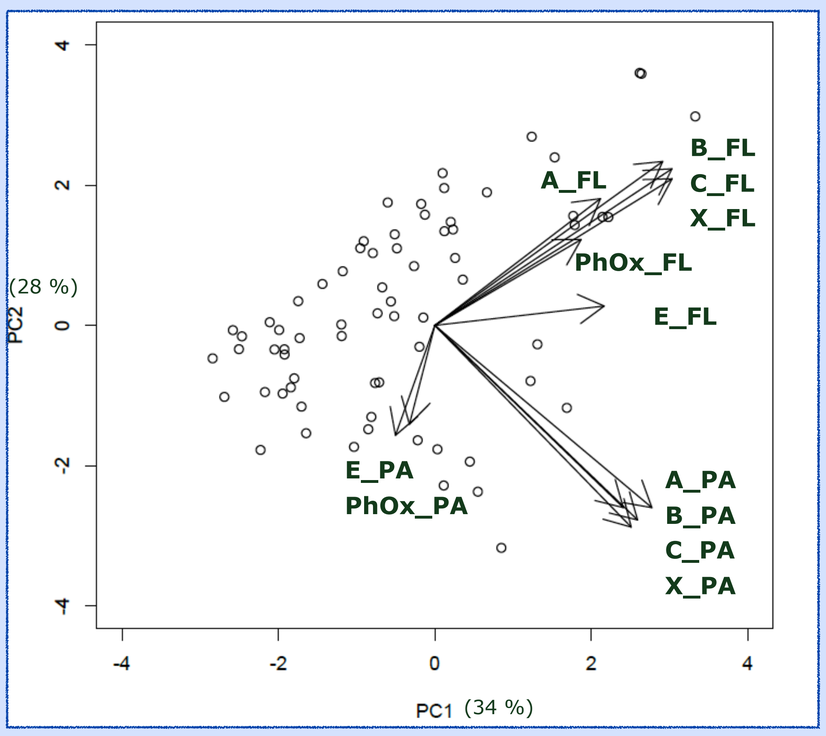


Fig. 3 Principal component analysis of enzyme activity patterns of FL and PA fractions

FL: free-living fraction
PA:particle-associated fraction

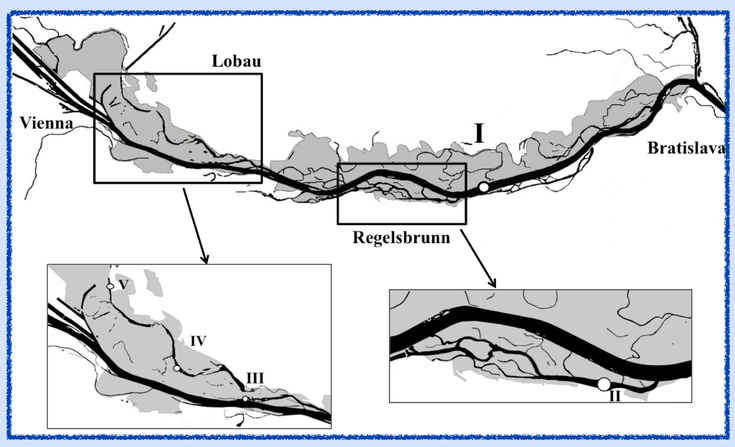
- Particle-associated enzymes and free-living enzymes are strongly interlinked what suggests a tight coupling within each fraction.
- The strong correlation between PhOx_FL and E_FL during flowing conditions ($r=0.77, p<0.01$) and E_PA and PhOx_PA during disconnected conditions ($r=0.67, p<0.0001$) suggests a tight coupling of enzymes responsible for utilization of labile and refractory material.

Conclusions

- Hydrological connectivity of floodplain lakes with the main channel is important factor which drives microbial enzymatic activity. Decreasing connectivity promotes activity of FL enzymes, whereas activity of particle-associated enzymes declines with decreasing connectivity.
- Of all the measured enzymes, PhOx_FL showed the most clear dependency on a gradient of connectivity ($r=-0.43$ $p<0.0001$), (Fig.1b). This implies that prolonged residence time in floodplain lakes allows more refractory material to be utilized.
- In dynamic river-floodplain systems, under variable hydrological settings, there is opportunity for enzymatic degradation of refractory material in the additional presence of enzymes responsible for utilization of semi-labile organic matter.

Study site

Sampling locations in the Danube river-floodplain near Vienna (Austria) which represent a gradient of connectivity to the main river.



Methods

Bacterial parameters

- Extracellular enzymatic activity (EEA)
  - C-acquiring enzymes:-β-d-glucosidase, α-d-glucosidase, β-d-xylosidase, cellobiohydrolase
  - N-acquiring enzyme:endopeptidase (Hoppe, 1993)
  - phenol oxidase (phOx) (Pind et al. 1994)
- Abundance (Porter and Feig 1980)
- Bacterial secondary production (Fuhrman and Azam, 1982)
- Extent of connection [m] (Peduzzi et al. 2008)
- DOM quantity and quality
  - DOC [mg l^{-1}] (Benner and Strom 1993)
  - DOM origin: FI ratio (McKnight et al. 2001)
  - Molecular size indicator: Slope ratio Helms 2008)
  - Aromaticity: $SUVA_{254}$ (Weishaar et al. 2003)
- Chlorophyl *a* (Lorenzen, 1967)

Acknowledgements

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