Hann (1995) investigaed the invertebrate association on *Ceratophyllum demersum, Potamogeton zosteriformis* and *Chara vulgaris.* Predominant were Cladocera, Copepoda, Rotifera, Chironomidae and Ostracoda. Most Cladocera preferred *C. demersum* and *P. zosteriformis which was un*expected because *C. demersum* and *Ch. vulgaris* are morphologically similar. Hann presumed that alelochemical characteristics were the reason for that. Hydra was mostly found on *C. demersum* and *P. zosteriformis* but it did not prefer any particular macrophyte species.

Macrophyte morphology can have a certain influence on invertebrate colonization (Dvořak 1996; Cheruvelil et al. 2000, 2002). Abundance of invertebrates is higher on plants with dissected leaves (Rooke 1984). These plants have a higher surface/biomass ratio and at the same time, they provide better shelter to invertebrates against predators and periphyton as available food resource. Hence, *Myriophyllum spicatum* L. is a suitable environment for brown hydra as proven by the maximum of 169 organisms on just one plant.

Elliott et al. (1997) investigated the predation of hydra to juvenile fishes in Opinicon Lake in Canada. Hydras were collected from *M. spicatum* where an average number of 63 organisms were found on about 20 cm long stems, which corresponds to our results. The authors concluded that as *M. spicatum* are more spread, the population of hydra is more numerous and the number of juvenile fishes is decreasing. They evidenced 26 % of larval mortality as many larvae died by the poison of hydras although they could escape from their stinging tentacles.

Hydras are certainly causing fish death especially of those which spawn in littoral lake zones (Elliott et al. 1997). The question how *Hydra oligactis* influences the fish population in Lake Gornjogradsko in Osijek is open for future investigation.

References

Bogut I (2005): Funkcionalna struktura makrofaune i meiofaune u makrofitskim zajednicama Kopačkog rita. Disertacija. Sveučilište u Zagrebu, Prirodslovno-matematički fakultet.136 pp. *[in Croatian]*

Cheruvelil KS, Soranno PA, Serbin RD (2000): Macroinvertebrates associated with submerged macrophytes: sample size and power to detect effects. Hydrobiol. 441, 133–139

Cheruvelil KS, Soranno PA, Madsen JD, Roberson MJ (2002): Plant architecture and epiphytic macroinvertebrate communities: the role of an exotic dissected macrophyte. N. Am. Benthol. Soc. 21(2), 261–277

Dvořak J (1996): An example of relationship between macrophytes, macroinvertebrates and other food resources in a shallow eutrophic lake. Hydrobiol. 339, 27–36.

Elliott JK, Elliott JM, Leggett WC (1997): Predation by Hydra on larval fish: Field and laboratory experiments with bluegill *(Lepomis macrochirus).* Limnol. Oceanogr. 42(6), 1416–1423

Hann BJ (1995): Invertebrate associations with submersed aquatic plants in a prairie wetland. UFS (Delta Marsh) Annual Report, 30, 78–84

Rooke JB (1984): The invertebrate fauna of four macrophytes in a lotic system. Freshwat. Biol. 14, 507–513

Microphytobenthos in large rivers – living on the edge

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Introduction

Rivers, especially their near bank zones and backwaters, are hot spots for biogeochemical processes (McClain et al. 2003) and represent functional retention areas, which are important for the control and maintenance of river water quality. Especially during low flow periods the importance of zones along banks for the aquatic productivity and therefore for the carbon supply increases along regulated rivers such as the Danube downstream of Vienna. These zones along banks provide essential flow reduced and shallow areas, important for zooplankton, juvenile fish and also the development of phytoplankton and microphytobenthos (Hein et al. 2005, Schiemer et al. 2007), which provide the basis for higher trophic levels. Studies from the Elbe show for example that the conditions in groin fields for planktonic primary production are much better than in the main channel. These boundary areas provide the main source for oxygen, organic matter and algal biomass for the whole river ecosystem (Böhme 2006). In the Danube River downstream of Vienna the formation of gravel structures along the riverbank allow the occurrence of microphytobenthos and support an increased emergence, although stabilisation measures and steep embankments have reduced these optimal growth zones *(Figure 1).* Bank restoration and embankment removal will improve the environmental conditions for microphytobenthos and therefore the basic supply for the riverine food web. Anthropogenic changes in bank morphology are therefore reflected in the production potential and biomass development of benthic algae and can be used as an indicator for the quality of bank structures. Beside this indicative value, they have been identified together with macrophytes as one of four biological quality elements for the assessment of the ecological status of surface waters.

Figure 1: Bank zone along the Danube near Hainburg. The front of the picture shows a shallow area with coarse gravel and characteristic phytobenthos development. In the back a steep embankment for bank stabilization is seen

Therefore phytobenthos is also a key element for the implementation of the EC water framework directive (WFD).

In addition to their use for international ecological assessment methods a better understanding of phytobenthic control factors and their ecological requirements is essential. Several control factors for microphytobenthos are known, but less on their impacts for these benthic algal communities in large rivers and their adjacent aquatic areas. General factors are light availability, nutrient availability, temperature and water velocity (Stevenson et al. 1996). In large rivers also water level fluctuations modify the development of microphytobenthos. Lowering of the water level causes desiccation stress for phytobenthic communities and suppresses growth and increases mortality. The impact of this environmental condition depends on the community structure and the duration of desiccation (Wetzel 2001). Turbulence has also an effect on the development of phytobenthos communities: for example ship induced waves are occurring frequently, but short lasting and increase the turbulence and resuspension of fine sediments at the habitat scale.

Therefore we identified three main control factors for the development and production of benthic algae in near bank zones:

– water level fluctuation
– fine sediment accumulation
– light availability

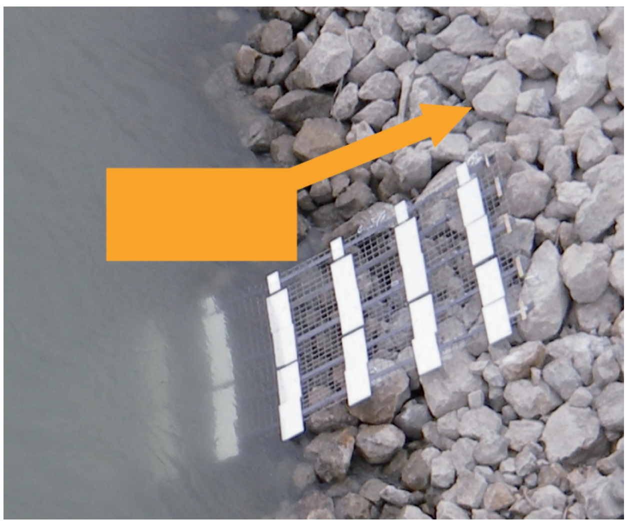
The aim of our study was to show how light limitations and risk of desiccation impact the development of benthic algae in the Danube River. We expected close to the water surface a better light availability, but also a higher risk of desiccation and fine sediment accumulation, while deeper areas are expected to be primarily light limited. More stable conditions result in a higher biomass development and a better light availability in shallow areas induces a positive effect on the productivity.

Phytobenthos depth distribution and fine sediment accumulation

Within a pre-impact monitoring program in the frame of the “Integrated River Engineering project” (IREP, Schabuss & Schiemer 2007) the depth distribution of phytobenthos and short term desiccation tolerance was investigated. An in-situ experiment consisting of the incubation of racks with artificial substrata (etched glass slides) exposed for a maximum of one month was conducted. Sampling took place in the free-flowing Danube section of the Austrian Alluvial Zone National Park at five dates in August / September 2006. Sets of etched glass plates were exposed along a water level gradient (MW ± 1.5m) to investigate the development of the community *(Figure 2).* Algal biomass, primary production and fine sediment accumulation were regularly measured.

The depth distribution of phytobenthos (average development time about one month) shows increasing chlorophyll a concentration to a depth of 61.6 cm with a maximum biomass of 16.0 ± 2.3 g/cm². With increasing depth the phytobenthos biomass decreased to a fourth of the maximum biomass *(Figure 3).* Reasons for this pattern are as follows: Close to the water surface water level fluctuations such as wave action represent high physical stress and decreases phytobenthos biomass. Short term desiccation stress, which can be caused by daily water level fluctuations, also suppresses phytobenthos development. At a water depth of 33.8 cm the risk of desiccation is low, but a high inorganic fine sediment accumulation (53.9 ± 31.4 mg/cm²) controls and reduces the light availability. At a water depth of 61.6 cm the highest phytobenthos biomass was measured. Daily water level fluctuations and desiccation play no significant role and also the fine sediment accumulation is lower. In this depth zone optimum growth conditions were observed.

Figure 2: Exposition of sets of etched glass plates along a water level gradient. The water level gradient included mean water conditions ± 1.5m. The construction was 3m long and was exposed at mean flow conditions. This construction included a total of 7 depth levels. The orange arrow indicates the water level fluctuations



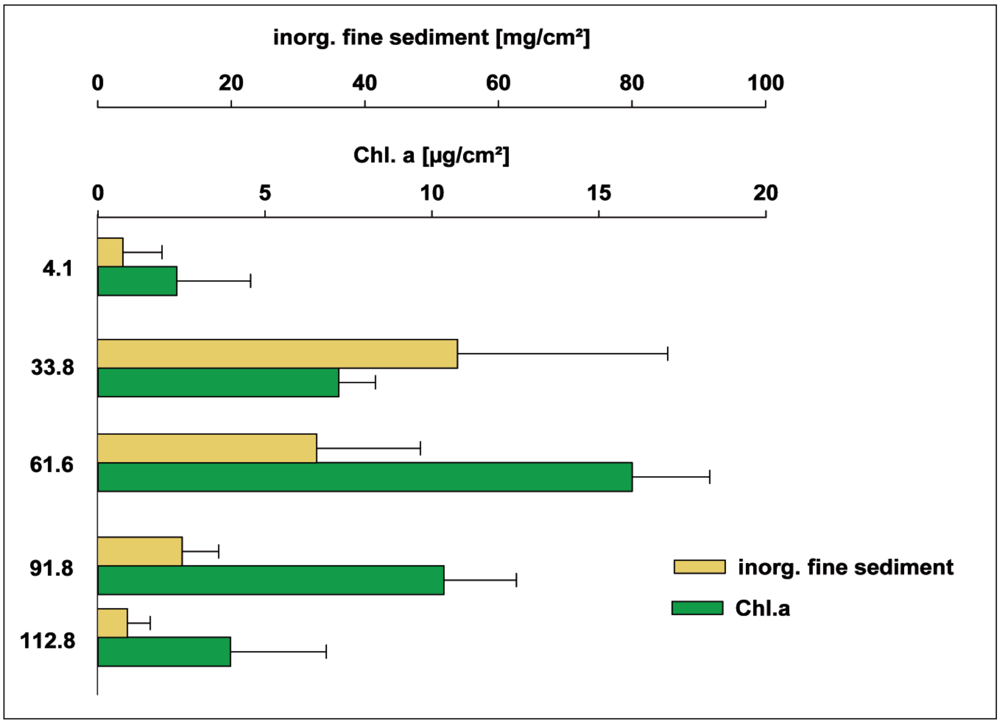


Figure 3: Mean phytobenthos biomass development and inorganic fine sediment accumulation (one month average and standard deviation). Highest biomass was found in a depth of 61.6 cm. Inorganic fine sediment accumulation decreases with depth

Considering the specific primary production (production related to biomass) it is notable that near the water surface the phytobenthic community has a higher specific primary production than the community in the optimal growth zone *(Table 1).* This indicates a high regeneration potential close to the water surface.

Mean water depth (cm)	Chlorophyll a Mean ± standard deviation	Specific primary production Mean ± standard deviation
4.1	2.4 ± 2.2 µg/cm²	17.3 ± 13.9 O2/Chla/h
61.6	16.0 ± 2.3 µg/cm²	3.8 ± 0.8 O2/Chla/h

Table 1: Chlorophyll a content and specific primary production of two selected depth levels

Summary and future aspects

Benthic algae provide an important nutrient source for higher trophic levels and support also the self purification potential in fluvial landscapes. These algal communities are confronted with various physical pressures such as wave action and long- and short-term desiccation stress. At longer dehydration periods a large part of the algae dies, or cysts for survival are generated. During these phases benthic algae play no significant role for the riverine production. Therefore measurements to determine the effects of short term desiccation stress on benthic algae are essential to obtain basic knowledge about the efficiency and development strategy as well as the sensitivity of this community to environmental changes. Bank reconstructions which create a close to nature morphology with various shallow and deep areas, can have positive effects on the production potential. A higher spatial distribution of microphytobenthos will be provided and result in a better and guaranteed supply for the food web at different hydrological conditions (low to mean flow). The understanding of the regulating processes for benthic algae will therefore provide a scientific basis for management decisions in the future, such as bank restoration measures and backwater reconnections in terms of combined effects of hydromorphological changes and is indicative to the effects of increased water level variability.

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References

Böhme M (2006): Wechselwirkungen zwischen den Gewässerkompartimenten. In: Stoffdynamik und Habitatstruktur in der Elbe (Eds M. Pusch & H. Fischer), pp. 209–217. Konzepte zur nachhaltigen Nutzung einer Flusslandschaft Bd. 5. Weißensee Verlag, Berlin

Hein T, Reckendorfer W, Thorp J, Schiemer F (2005): The role of slackwater areas for biogeochemical processes in rehabilitated river corridors: examples from the Danube. Arch. Hydrobiol., Large Rivers 15, 425-442

McClain ME, Boyer EW, Dent CL, Gergel SE, Grimm NB, Groffman PM, Hart SC, Harvey JW, Johnston CA, Mayorga E, McDowell WH, Pinay G (2003): Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. Ecosystems 6(4), 301-312

Schabuss M, Schiemer F (2007): Key threats to the Danube in the IAD perspective. No.1, Navigation: is there a potential for compromising the contradictory stakeholder interest? IAD Danube News 15, 2-4

Schiemer F, Hein T, Reckendorfer W (2007): Ecohydrology, key-concept for large river restoration. In: Ecohydrology and Hydrobiology 7 (2), 101-111; ISSN 1642-3593

Stevenson RJ, Bothwell ML, Lowe R (1996): Algal Ecology Freshwater Benthic Systems. Academic Press, Inc. San Diego, California

Wetzel RG (2001): Limnology. Lake and River Ecosystems. Third Ed. Academic Press, San Diego. xvi, 1006 pp. ISBN 0-12-744760-1