The effect of riverbed management on the habitat structure and macroinvertebrate community of a ninth order river, the Danube in Austria

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Sediment parameters

Although the selected grain size (60 x 130 mm) of the sediment that was added to avoid further bed deepening was a result of hydrological experiments in the laboratory (Ogris 1989), based on the results of the field test, the desired outcome was not achieved for the whole sampling period of about three years. After an initial increase of the grain size parameters Q2 and Q3 and a decrease of the coefficient of sorting in the top layer as a consequence of the addition of the coarse material, the particle size in the top layer decreased and the coefficient of sorting increased at sampling date 3 and 4, after more than one and a half years (Fig. 1a). The latter is due to conveyance of top layer material downstream and the mixing of top layer material with subsurface material. Apart from these effects on the habitat structure, the main changes occurred in the hyporheic zone, where the pore space decreased considerably — the higher stability of the top layer led obviously to a certain degree of colmation and consequently to less pore space (Fig. 1b).

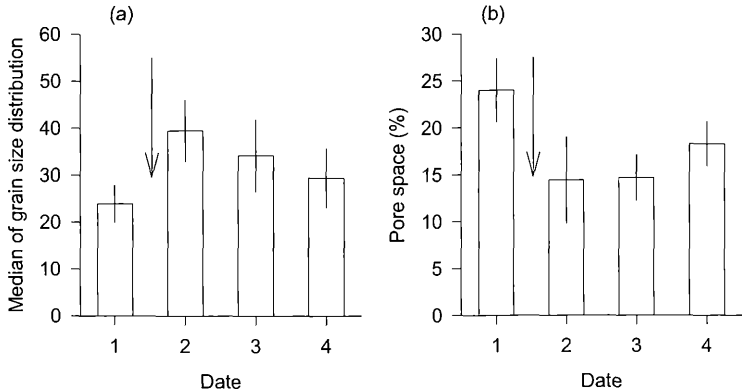

Fig. 1: Changes in a) grain sizes and b) pore space after the addition of coarser grain sizes (indicated by an arrow). Dates 1 to 4: before, 6 moths after, 18 months after and 3 years after the addition.

Macroinvertebrate response

Effects of gravel replacement on the macroinvertebrate fauna were studied by Boles (1981), but because the replaced gravel was too small it did not support the diversity of organisms found on natural riffle gravel.

The impact of the present riverbed management on the macroinvertebrate community can be discussed under two aspects: the surface and the hyporheic fauna. The time for a complete recolonization of the surface of a riverbed, e.g. after coarse material has been added, takes in streams about four to six weeks (e.g. Coleman & Hynes 1970). Because the second sampling of the present investigation occurred six months after the layer of coarse material has been added, it is concluded, that a complete recolonization through drift and migration had taken place (Williams & Hynes 1976). The total mean drift rate of macroinvertebrates in the Danube is estimated to be 13.6 million animals per 24 h (Anderwald et al. 1991). The increase in particle size created stability, in the sense of resistance of surface bed sediments to movement, which may account for the increase in total number of individuals from the first to the second sampling date (Fig. 2). As the particle size later decreased up to the fourth sampling date, the number of individuals also decreased. The latter relationship is discussed in detail by Minshall (1984), but there is a lack of agreement between studies on the direct relationship between mineral particle size and numbers of invertebrates (e. g. Williams & Mundie 1978; Malmqvist & Otto 1987; Williams 1980; Williams & Smith 1996).

The depth of penetration of macroinvertebrates into the sediment is related to the degree of sediment compaction. In closely packed materials, such as the mud bottoms of streams, penetration does not exceed about 40 cm (Ford 1962; Strommer & Smock 1989). But where substantial interstitial flow occurs, distribution may extend to a meter or more (Minshall 1984). In the present study, in depth zone 90 to 100 cm Turbellaria, Oligochaeta, Hydracarina, Crustacea and Chironomidae could be detected on sampling date 1. Similar vertical or depth distributions are known for other gravel streams and rivers (e.g. Williams & Hynes 1974; Bretschko 1992). As already mentioned, as a consequence of the higher stability of the top layer, the mixing relationships in the hyporheic zone became altered and, thus, had a severe impact on this environment. The refugial space for the macroinvertebrates becomes reduced by siltation of the interstices and the sealed interstices cannot function as an environment (e. g. nurseries) for the benthos (Brunke & Gonser 1997). The latter could be detected in the present study; while the pore space differed with depth between 16 – 28 % at sampling date 1, a marked decrease down to about 7 % could be shown for sampling date 2 and 3, with a recovery after three years (sampling date 4) of up to 16 – 27 % pore space. This recovery is probably due to the conveyance of some top layer material downstream and also the mixing of top layer material with the subsurface material. This change in habitat structure was followed by a change in the macroinvertebrate community, e.g. vertical distribution of the animals (Fig. 2). Whereas > 90% of the total number of individuals colonized the space between 0 and 90 cm on sampling date 1, the depth distribution was restricted to 50 and 40 cm on the other sampling dates. The latter relationship was supported by PCA and Cluster-Analysis and agrees with Maridet et al. (1992). In contrast to these results, Minshall (1984) states, that there is little evidence of the importance of pore space to freshwater invertebrates, and according to the studies of Williams & Mundie (1978), Khalaf & Tachet (1980) and Williams (1980), where pore space has been determined in relatively natural settings, no significant correlation could be shown between pore space and number of macro-invertebrates.

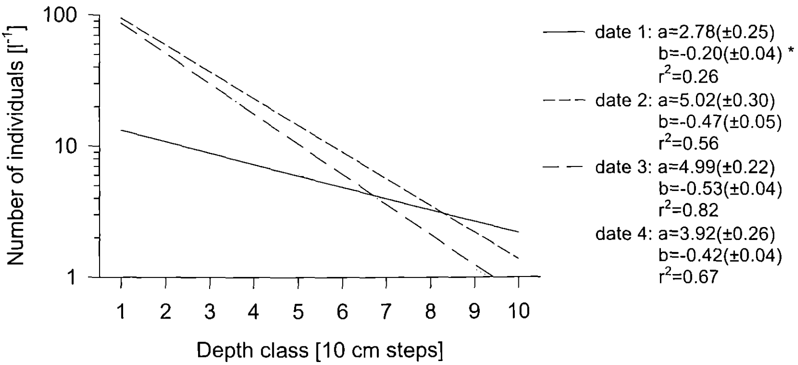

Fig. 2: Decrease of total numbers of individuals with sediment depth at the four sampling dates, according to the regression formula: ln(Y) = a + b X, where Y = total individual numbers per liter, X = sediment depth class, a and b = constants (± standard error). Dates 1 to 4: before, 6 moths after, 18 months after and 3 years after the addition. The asterisk indicates a significantly different slope of date 1 compared to all other dates.

Williams (1984) suggested that the animals living in the interstices of riverbeds can be divided into two types: the occasional and the permanent hyporheos. The occasional hyporheos consists of development stages of most of the surface benthos that may choose this zone as a refuge during their (early) development. Seasonal variations in the distribution of these stages might occur. The permanent hyporheos consists of many specialized forms that complete their life cycle there, e. g. Crustacea, Oligochaeta, Hydracarina. One of the most important advantages of living in the hyporheic zone is that of survival during adverse river conditions, e.g. droughts or spates. Therefore the hyporheic fauna may act partly (Palmer et al. 1991) or in general (Dole-Olivier et al. 1997) as a source of recolonizing animals should any severe disturbance happen to the surface benthos. The present study shows that the potential for recolonization decreases with decreasing pore space as a consequence of the present riverbed management.

The bottom substratum is a primary factor influencing the abundance and distribution of macroinvertebrates (Reice 1980). It acts directly on the animals as a medium for their existence, and indirectly as a major modifier of their environment (Ward & Voelz 1990). However, it is also true that the substratum rarely, if ever, exerts its influence in isolation (e.g. Williams & Smith 1996; Dole-Olivier et al. 1997).

References are given in:

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