Comparative analysis of biotic indices based on macroinvertebrate communities

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Introduction

Ecological river state assessment based on biotic indices of macroinvertebrate communities can be used most efficiently in small streams with their relatively uniform morphology and hydrology. In large rivers, such as the Danube, where fluvial processes modified by human disturbance produces a sophisticated dynamic system, the standard sampling and evaluation techniques primarily created for small streams can only be applied under certain conditions and/or after appropriate modifications (Oertel 2000). Between 1999 and 2001, every third week macroinvertebrate communities were sampled at the Hungarian Danube section of Göd (river km 1669), using the methods of kick & sweep (**K&S**) and of artificial substrate exposition. The data set, consisting of 125000 macroinvertebrates identified to species level, provided a basis for comparing the saprobic (**SI**) and the water quality (**QI**) indices and to evaluate their applicability.

Material and method

Two types of substrate (gravel (**G)** and clay granules (**C**)) and two types of location in space (water surface (**S**) and river bottom (**B**)) were combined in long- and short-period-colonization experiments (**LPC** and **SPC**, respectively). During the **LPC** experiment samples were taken in every three weeks, so the sample taken first was exposed to the river water up to three weeks, while the sample was last to take remained in water up to thirty weeks. During the **SPC** experiment, in every three-week period, samples were taken and the substrate material consecutively was replaced. The types, size and arrangement of the artificial substrates, the experimental layout, sampling frequency and the proceeding of the samples were described in former papers (Oertel 2002, Nosek 2002). The saprobic index (**SI**) (Gulyás 1998) and water quality index (**QI**) of the Hungarian Macrozoobenton Family Score system (**HMFS**) (Csányi 1998) were compared in the samples taken concurrently. Csányi elaborated HMFS after the adaptation of the BMWP score system (NRA 1990) to Hungarian conditions. QI is calculated as the mean of the cumulative score of HMFS and the average taxon per score (ASTP). In the case of SI, the absolute number of individuals was used.

Results and discussion

During the study period, 125000 specimens of 37 macroinvertebrate species belonging to 28 families were collected. The 12 higher taxa included (family/species number in brackets): Bryozoa (1/1), Platyhelminthes (1/1), Gastropoda (6/8), Lamellibranchiata (2/2), Polychaeta (1/1), Oligochaeta (1/1), Hirudinea (2/2), Mysidacea (1/1), Isopoda (1/1), Amphipoda (2/3), Ephemeroptera (4/8), Triphoptera (6/8).

Although the saprobic index based on kick & sweep sampling varied seasonally – lowest in early spring and late fall, maximum in summer, and had very low standard deviations

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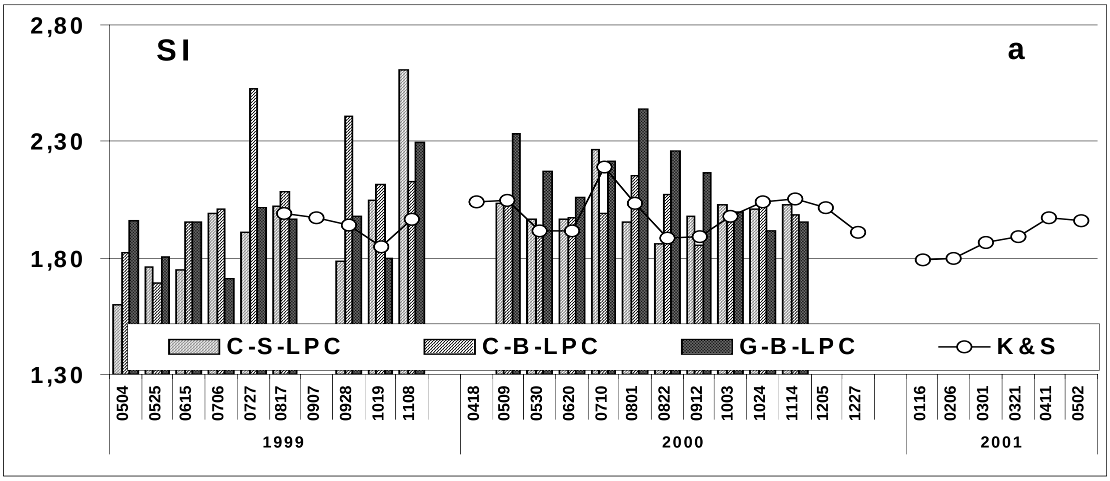
throughout the study period – the water quality of the Danube section investigated was clearly within the range of the β-mesosaprobic class (Figure 1a). The temporal change of SI calculated on the basis of artificial substrate samples of long-period-colonization differed year by year and showed higher deviations than the SI based on kick & sweep sampling. For example, in 1999 the data indicate a deteriorating water quality with permanent increase of SI from early spring to late autumn and which spread over a wide range of oligo-β-mesosaprobic and α-β-mesosaprobic classes for all substrate types.



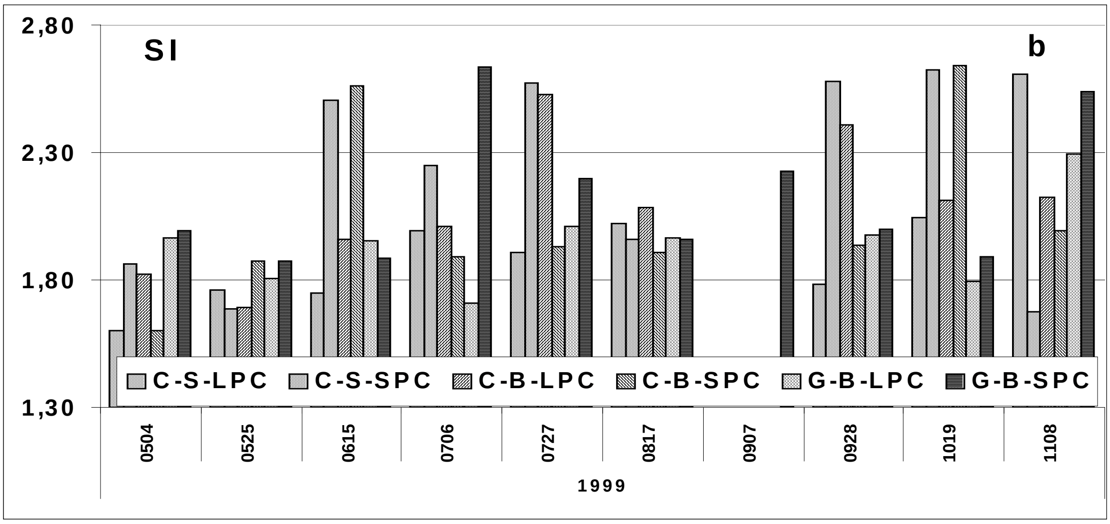


Figure 1. Changes of the saprobic index, based on different sampling techniques of macroinvertebrate communities between 1999 and 2001 (C-S-LPC = clay–surface–long-period-colonization, C-S-SPC = clay–surface–short-period-colonization, C-B-LPC = clay–bottom–long-period-colonization, C-B-SPC = clay–bottom–short-period-colonization, G-B-LPC = gravel–bottom–long-period-colonization, G-B-SPC = gravel–bottom–short-period-colonization, K&S = kick & sweep).

SI values based on colonization of different substrate types more or less differed within the same sampling periods. This can be seen clearly in Figure 1b, which shows the outcomes of short- and long-period-colonization experiments in 1999. These results reflect different pathways of colonization and the selectivity of the artificial substrates, which differ in their quality and spatial location (Nosek 2002, Oertel & Nosek 2006).

With respect to the variability of the SI values, sampling procedures are ranked as follows: kick & sweep sampling (CV%: 3-5); long-period-colonization (CV%: 4-16); short-period-colonization (CV%: 13-21).

Figure 2. demonstrates the effect of sampling techniques on water quality index changes in time, based on the macroinvertebrate communities. Throughout the study, the QI shows higher variability than the SI almost in all cases.

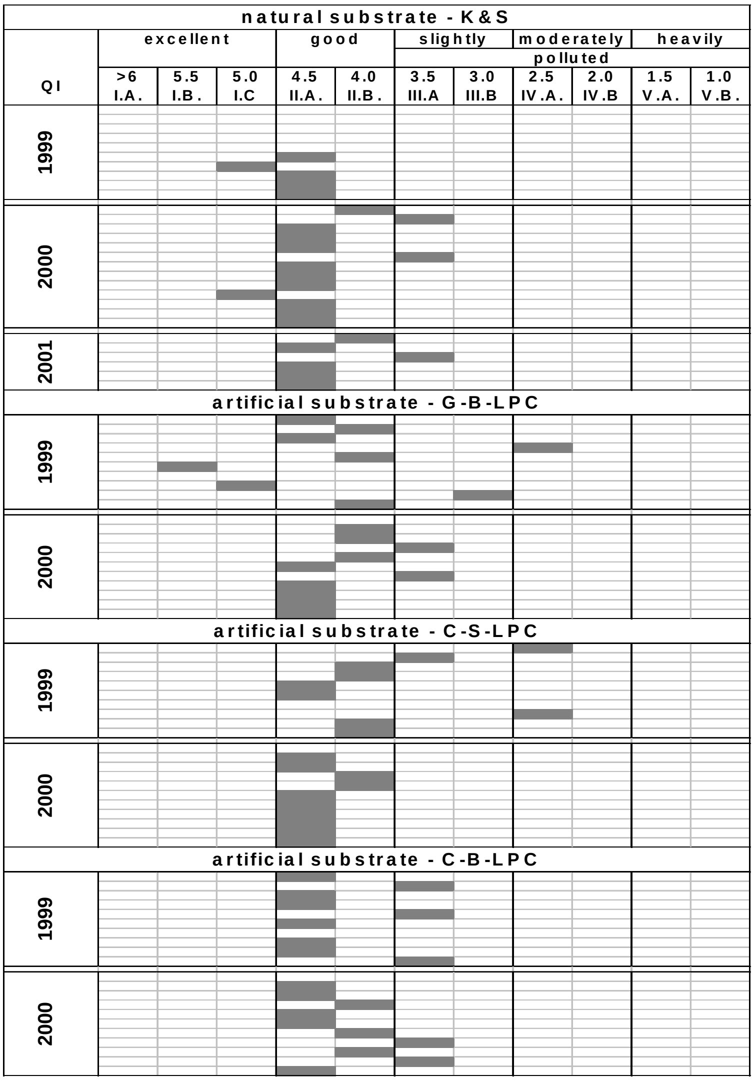


Figure 2. Changes of the water quality index (given as water quality scale) based on different sampling techniques of macroinvertebrate communities at Göd (river km 1669) (C-S-LPC = clay–surface–long-period-colonization, C-B-LPC = clay–bottom–long-period-colonization, G-B-LPC = gravel–bottom–long-period-colonization, K&S = kick & sweep).

QI values of the kick & sweep sampling and that of the long-term-colonization experiments using artificial substrates significantly fluctuated within the three-week short periods, changing two or three water quality categories on the water quality scale of five classes and 11 subclasses. Short-period-colonization experiments showed similar patterns and variability. There were differences between the years: in 2000 the data were less variable, and in short time experiments the range was down to 1 or 2 water quality subclasses.

With respect to both indices, the kick & sweep technique sampling the natural gravel substrate indicated better water quality, than the artificial gravel substrate exposed at the bottom. Surface exposition of clay substrate yielded similar or a slightly improved QI rankings than bottom exposition. The results of the long-period-experiments always indicated better quality of the river water than that of short period expositions.

Figure 3 demonstrates independence – the lack of correlation – between the data of SI and QI. During the whole period studied, a relatively wide range of QI could be observed within the β-mesosaprobic class, which is characteristic for the given Danube section. Just et al. (1998) also reported a lack of correspondence between sabrobic index and ASTP at the river section downstream of Budapest.

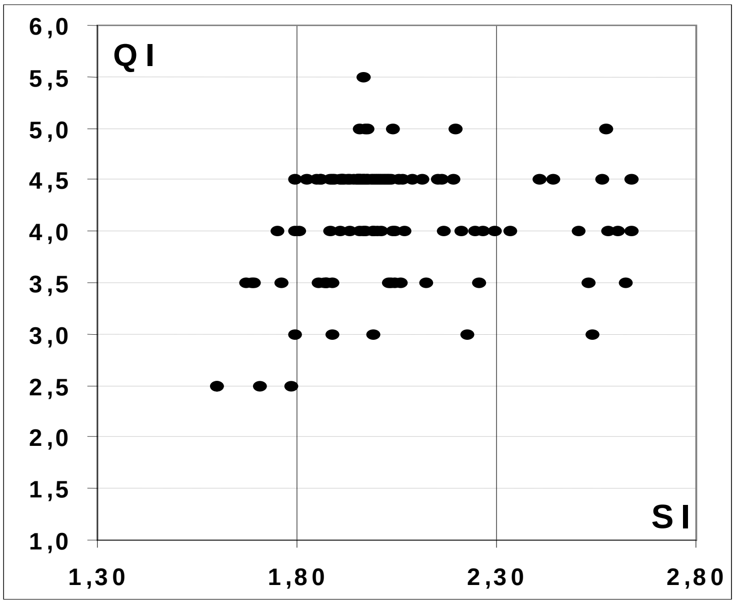


Figure 3. Correlation between saprobic and water quality indices of macroinvertebrate communities between 1999 and 2001 at Göd (river km 1669; N=109).

Conclusions

The QI values calculated from the cumulative scores and the average score per taxon based on the Hungarian Macrozoobenton Family Score system are more variable than the SI, and significantly fluctuates within the three-week short periods, ranging over 2 or 3 classes of water quality.

The siginificant fluctuation of the biotic indices (mainly that of QI), which was observed during the very frequent sampling procedure raises the following questions: How can this fluctuation be interpreted? How is it possible to distinguish between sites when the variability in time is greater? Is it possible to use any kind of data averaging with high standard deviations for the characterization of longer time periods? How many samples per year and which samplings are acceptable for ecological state assessment?

The differences between saprobic and water quality indices may be explained as follows: 1. The original BMWP score system was elaborated for relatively small, organically polluted rivers,. In large rivers consisting of discontinuous sections, and exposed to significant and complex human disturbances, the biotic score could only be useable and interpretable under certain restrictions. 2. The differences between the two indices may be also due to the different levels of identification. We have to face a loss of information when evaluating 28 families instead of 37 species used in the calculation of the saprobic index. Moreover, SI calculations use the number of individuals whereas the family score system does not.

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