

Usage of biotic indices in evaluating the impact of the urban centres on the quality of the water in rivers

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Abstract. The quality of the river waters of the Crișul Repede River and the influence of the powerful urban and industrial centre Oradea upon these have been studied by means of collecting quantitative samples of benthos, for three consecutive years, in a seasonal manner. The calculation of the biotic indices that consider the abundance of benthic macroinvertebrates indicating the presence of high qualitative waters (Ephemeroptera, Plecoptera and Trichoptera) and of those indicating strong loading of the waters and of the under layer of the water ecosystem with organic matter (Diptera – Chironomidae Family), highlighted an advanced degradation of the water quality, from the upstream towards the downstream. Equally, the intensity of the process of degradation of the water quality has been established, which, in the case of this river, is very strong and visible by the increasing prevalence of groups that do not require special ecological conditions, proving to be resistive and even proliferating in the presence of intense pollution of the water.

Key Words: biotic indices, EPT, Chironomidae, macroinvertebrates, water quality.

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Introduction

The equilibrium of the lentic water ecosystems is very delicate, because the surface area has a relative stability, resisting only to slight modifications of the condition parameters. The macrozoobenthic organisms are completely exposed to the modifications of the environment, not disposing of various possibilities of leaving the affected environment and of settling in a new habitat (Petrovici 2009). Any modification of the physicochemical factors produces corresponding modifications in the structure and in the specific composition of the biocenosis (Filimon *et al* 2010). The proportion of the different species is also affected, as well as their distribution in space and their dynamics in time, and their interspecific relations.

One of the major causes of the modification of these physicochemical factors is the location on the river streambed of urban and / or industrial centres that are performing caption and discharging of residual waters in the river, as well as the way of usage of the site and the intensity of agricultural activities on the site (Getwongsa *et al* 2010).

The evaluation of the impact that an urban and industrial centre has on the water quality, analysing both the modification of the physicochemical factors as well as the changes that appear in the structure of the benthic macro invertebrate community, has been the topic of many studies so far, carried out on various rivers (Badea *et al* 2010; Marin *et al* 2011; Rácz *et al* 2010; Răescu *et al* 2011; Stoian *et al* 2009, Vincze *et al* 2011).

The present study approaches the matter of evaluating the impact of the urban and industrial centre Oradea on the water quality of the Crișul Repede River, taking in consideration the modification of the values of the most utilized biotic indices (Wallace *et al* 1996). To this effect, the following biotic indices were taken in account: EPT Count, EPT/Total Count, Chironomidae Count, EPT abundance/Chironomidae abundance, % abundance of Chironomidae larvae.

Material and Method

The Crișul Repede River (length = 107 km) flows in the north-western region of Romania, being the major tributary of the Tisa river. The catchment area is of about 1,437 km², and it is irregular, because its tributaries streaming from the Meseș – Plopiș Mountains are almost non-existent (Petrovici 2009). Two sites were selected on the reaches of the river, in order to investigate the changes that are induced on the water quality by the city of Oradea, an important urban and industrial centre (over 200,000 inhabitants). The first site, *Fughiu site*, is situated at about 10 km upstream of the city (140 m altitude), in a highly agricultural region. The width of the streambed is of 50-60 m, and its average depth is of 40 cm. The average water speed is of 0.8 m/second, and the sediment is equally made out of rocks and grit, that have allowed accumulation of slopes of sandy sediments. Near the banks, the sediment is mostly made out of sand, with thick slopes of ooze. The second site, *Cheresig*

site (94 m altitude), is situated at 30 km downstream of the city, at a distance of 2 km of the state border line. The width of the streambed is of 60-70 m, and the depth and the average water speed is of 50-60 cm and respectively 0.9 m/second. The under layer is made mostly of sand and the grit is present only in a small proportion, with many oozy deposits.

The samplings were collected in a seasonal manner (spring, summer, autumn), in the period 1996-1998, by using a Surber sampler (1060 cm² surface, mesh size 250 µm). Three samplings (replicates) were collected from each site, in order to be able to calculate an average value. The samplings were entrenched, in formaldehyde 8%. Afterwards, the samplings were sorted, and the respective organisms were sorted and numbered, then separated according to the reign, except the midges, that were sorted only by family-level (Ord. Diptera – Chironomidae Family).

In order to evaluate the water quality, the following biotic indices were taken in account (Hellowell 1986):

Ephemeroptera Plecoptera Trichoptera Count (EPT Count): Count of the number of individuals in the three generally pollution-sensitive orders – Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). A high variety is good.

EPT/Total Count (EPT/T Count) EPT count divided by the total number of individuals in the sample. A higher number is good.

Chironomidae Count (Ch Count): Total of individual Chironomidae (midge larvae) collected in sample.

EPT abundance/Chironomidae abundance (EPT/Ch Count): EPT count divided by Chironomidae count. A lower Chironomidae abundance is good.

Total Count (T Count): total of macroinvertebrates individuals.

Percent (%) of abundance of Chironomidae larvae (Ch abund): Compares the number of Chironomidae to the total number of organisms in the sample. (The number of organisms in the Chironomidae family is divided by the total number of organisms in the sample to calculate a percent composition). A low percentage is good.

Results and Discussions

The sorting of the biological material collected (54 benthos samplings) up to a reign or family-level, proved that in the benthos from the Fughiu site, all groups of macroinvertebrates specific to this particular river sector are present. Thereby, we encountered alongside Plecoptera, Trichoptera, Ephemeroptera (groups that are taken in account when calculating the EPT Count, EPT/T Count, EPT/Ch Count indices), the presence of Chironomidae, Oligochaeta, Acarina, Coleoptera, Nematoda, Collembola, Odonata, Isopoda, Hirudina, Turbellaria, Gastropoda, Lamellibranchiata and Amphipoda. All these groups were taken in account when calculating the EPT/T Count and T Count indices.

In the benthos of the Crişul Repede River present on the Cheresig site, we encountered only the following: Chironomidae, Trichoptera, Ephemeroptera, Oligochaeta, Nematoda, Acaria, Coleoptera, Isopoda, Hirudina, Turbellaria, Gastropoda and Lamellibranchiata. On this site, the Chironomidae and the Oligochaeta compose about 94% of the total benthic macroinvertebrate community.

The calculation of the EPT indices for the two stations (Figure 1, up-left), indicates higher values of this index at the site situated upstream of the city than at the site situated downstream, during the entire period of study. The highest values of the

index were encountered during the entire period, in the spring season, followed by a decrease of the number of individuals of the three groups.

At the Cheresig site, the EPT indices have low values (oscillating between 1 and 11), except for the summer of 1998, when the value 33 was recorded, after the identification in the samplings of a record number of Ephemeroptera (22). These were identified to be part of the *Baëtis vernus* species that did not present strict ecological criteria, supporting a higher degree of degradation of the water quality (Gâldean 1992; Hellowell 1986).

The same pattern of variation presents the EPT/T Count index (Figure 1, up-right - Figure 1.b), but on another scale of values, because the sum of the individuals from the three groups indicating the presence of high qualitative waters is divided, in this case, at the number of individuals present in the whole macrozoobenthic community. Therefore, this index becomes very low and has a constant value (lower than 0.05) on the Cheresig site, where the reduced number of Ephemeroptera and Trichoptera individuals is divided to the great number of Chironomidae and Oligochaeta, which are numerically dominating the benthic community. The great number of Chironomidae on the Cheresig site (Figure 1, middle-left - Figure 1.c), indicated a heavy loading of the underlayer of the Crişul Repede River with organic substances, that was also certified by (Răescu *et al* 2011) for the Cerna River, after its waters had travel through a large urban centre.

The model of the variation of the number of Chironomidae (Figure 1, middle-left - Figure 1.c) and of the total number of macrozoobenthic organisms (Figure 1, down-right - Figure 1.f) are similar, only the scale of values being different. This can be explained by adding it at the number of Chironomidae and Oligochaeta present on both sites. The increased affluence of the two groups underlines once more the strong influence on the water quality of the Crişul Repede River that the city of Oradea has, both groups being characteristic to heavily-loaded water ecosystems and to sedimentary organic matter.

Figure 1, middle-right, indicates this, with very low values of the EPT/Ch Count index on the Cheresig site, in comparison with the values of the same index, but on the site situated upstream of the city. This index is considered by Hershey and Lamberti (2001) the most popular community level metric used in biomonitoring. In the case of the Crişul Repede River, after the river travels through the city of Oradea, the value of the index decreases very much (even by a few hundred times, e.g. the spring and the autumn of 1996 and, respectively, the autumn of 1997). A decrease of this index has been tracked down by (Răescu *et al* 2011; Dumbravă-Dodoacă & Petrovici 2010; Wang *et al* 2012) too, after the river has travelled through an urban centre, but in this case the index decreased only by a few times, from values of 0.17 and 0.28 in the upstream sector, to values of 0.56 and 0.67 in the downstream sector. The differences presented can be related to the differences of the impact that the two cities had on the water ecosystems. Thereby, the city of Oradea had a major, overwhelming impact on the water quality of the Crişul Repede River, as it is an important urban and industrial centre, while the city of Băile Herculane has only a smaller impact on the water quality of the Cerna river, as it has fewer inhabitants and its industrial sector is not as developed as the one of Oradea.

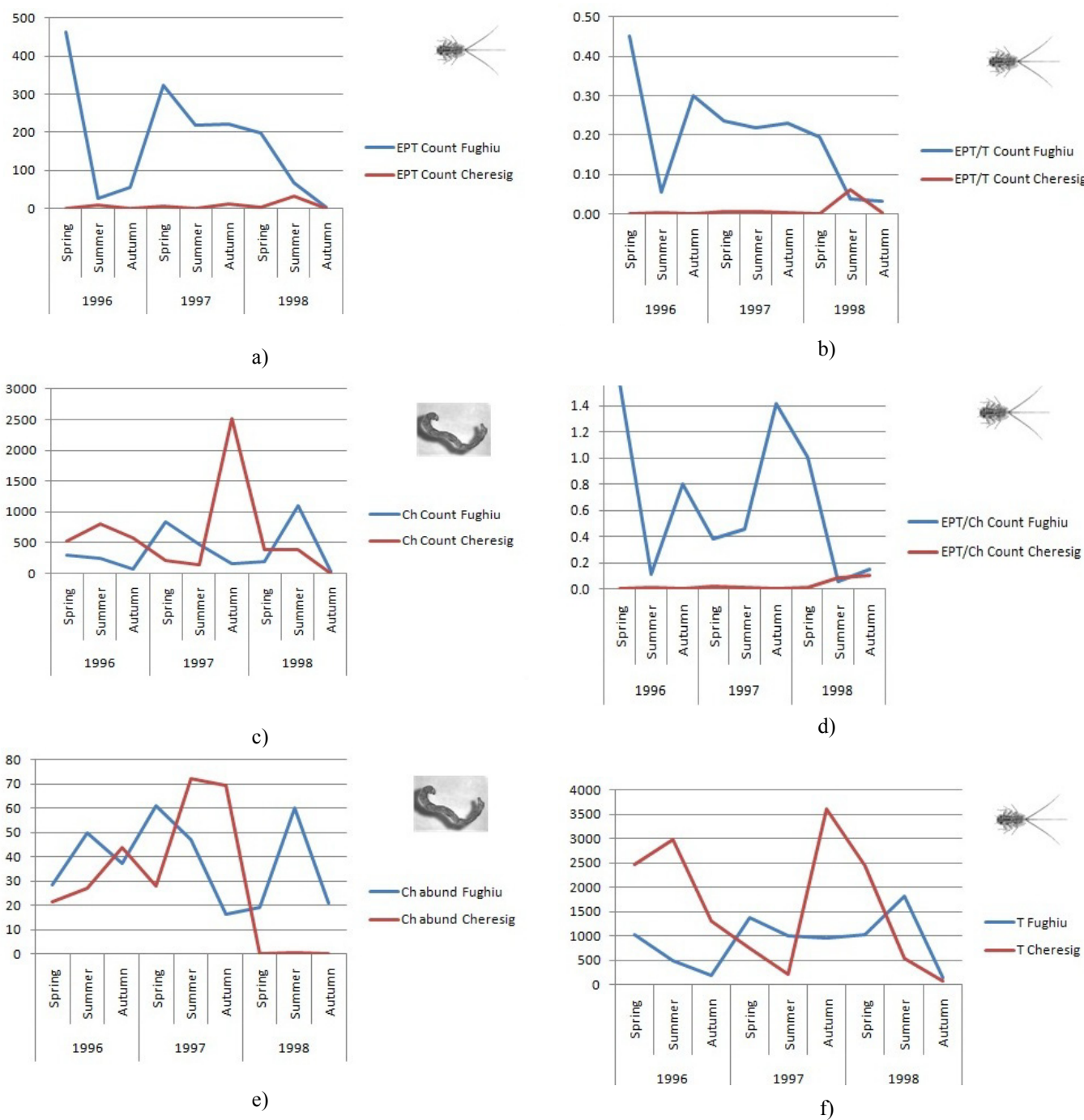


Figure 1. Season variation of the biotic indices at the Fughiu and Cheresig sites, Crişul Repede River, 1996-1998 (For abscissa: the seasons are Spring = March-May, Summer = June-August, Autumn = September-November. For ordinate: values of biotic indices: a) EPT Count indices; b) EPT/T indices; c) Ch Count Indices; d) EPT/Ch Count indices; e) Ch abund indices; f) T Count indices)

Conclusions

The calculation of the biotic indices that consider the abundance of benthic macroinvertebrates indicating the presence of high qualitative waters and of those indicating strong loading of the waters and of the underlayer of the water ecosystem with organic matter is an appropriate method of studying the water quality level of a water ecosystem. In the case of the Crişul Repede River, this analysis highlighted an advanced degradation of the water quality, once the river has travelled through the urban and

industrial centre Oradea. Equally, the indices calculated have highlighted the intensity of the process of degradation of the water quality, which, in the case of this particular river, is very strong and visible by the increasing prevalence of groups that do not require special ecological conditions, proving to be resistive and even proliferating in the presence of intense pollution of the water.

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