INFLUENCE OF THE CONSTRUCTION OF THE TURČEK RESERVOIR ON THE ORGANISMS OF THE RIVER BOTTOM

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ABSTRACT

We found that an increased erosion in the river ecosystem causes the increase of the anorganic material in the water column which have negative influence to periphyton. The erosion manifests itself in great fluctuations of the abundance and biomass of Ciliophora (April - September). With macrozoobenthos a marked drop of their abundance and diversity takes place. The trophic structure of micro- and macrozoobenthos is being changed, i.e. a decrease of the ratio of collectors takes place (Oligochaeta, Chironomidae - representing the most important part of interstitial fauna of macrozoobenthos) as well as with grazers. These negative influences reflect (manifest itself) in the marked macrozoobenthos production decrease and microzoobenthos abundance and biomass increase.

KEYWORDS: siltation, detritus, periphyton, zoobenthos, seasonal dynamics, trophic structure, metarhithral.

INTRODUCTION

Long term hydrobiological research in the basin of the Turiec River, a tributary of the Váh, (KRNO et al. 1994), pointed to the high biological value of this region. In this work we aimed at a brief analysis of the results gained in the years 1987-93, in the upper Turiec basin, with the aim of identifying the changes, which occurred in the preparatory phase of the construction of the Turček Reservoir, and in particular the increased erosion found in the upper course of the stream.

MATERIAL AND METHODS

In the years 1987 - 88 and 1992 - 93, a site was chosen above the village of Sklené (7972, DFS), for study of the metarhithral throughout the year. In the first period, the profile was studied at two to three month intervals, and in the second period at regular monthly intervals from March 1992 to February 1993. At the beginning of 1992, the construction of the Turček Reservoir was started. Intensity of the preparatory work increased at the beginning of summer, (removal of woods, use of heavy machines), and resulted in increased erosion in the upper part of the stream.

We carried out the methodical evaluation of the physical geographical and hydrobiological characteristics of the site according to KRNO et al. (1994).
We followed the methods of physiogeographical characteristics evaluation according to PLATTS et al. (1983).

We sampled microzoobenthos (with special accent upon Ciliophora) at partial sections of the Turiec river from three types of substrat: mud - detrit, plants and rocks. Microzoobenthos was collected directly to glass bottles with the volume of 200 ml (a layer of sediment of about 1 cm). We processed all samples in the vital state. From each sample we pipetted 1 ml or 1 cm$^3$ of a sediment, where we enumerated all individuals occurring. From fixation and colouring methods we used a method of protargol impregnation for Ciliophora according to WILBERT (1975).

Macrozoobenthos, wood and CBOM were collected by benthometer from riffles 1,500 - 2,000 cm$^2$ (3 - 4 collections), from pools 1,000 - 1,500 cm$^2$ (2 - 3 collections).

FBOM and UBOM was isolated by using of the sharply edged tube inserted 10 - 15 cm into the substrat. After replacement of stones the bottom was thoroughly whirled several times to a depth of about 5 cm. 0.5 l of water was taken from water column and this procedure was repeated 2 - 3 times.

For assessing of transported organic matter (TOM), 2 - 3 litres were taken from the stream flow.

Quantitative periphyton and macrophytes samples were scraped from 7 - 10 rocks according method of PUNČCHOVÁ (1986). The P/B coefficient (ZELINKA et al., 1984) was used for calculation of primary production which was multiplied by the ratio of illuminated substrat surface under 1 m$^2$ of water surface.

The macrozoobenthos biomass was determined directly as wet formalin mass. All quantitative biotic factors (periphyton, macrophytes, detrit, macrozoobenthos) are expressed in ash free dry matter (AFDM). Dry biomass of macrozoobenthos taxa was estimated from the known length - weight relations (SMOCK, 1980). The secondary production of zoobenthos was evaluated by and the size-frequency method (MENZIE, 1980).

We found the values of saprobial valence, indicative balance and saprobity index according to list of indicators of water quality (SLÁDEČEK, 1981) revised by FOISSNER (1988).

The actual water temperature, 48 hours mean temperature, the quantity of dissolved $O_2$, $BOD_5$, $Ca^{2+}$, $NH^+$, $PO_4^{3-}$, $pH$ were measured. Data on some basic abiotic factors are given in Tab. 1.

RESULTS AND DISCUSSION

To compare 2 time periods at the locality, we recorded a series of changes in the structure and dynamics of various parameters, which originated as a result of the preparatory work for the Turček Reservoir, and were manifested in the following indicators:

Transported organic matter (TOM), transported anorganic matter (TAM), benthic organic matter (BOM) and periphyton. TOM had two peaks during the year, one in March and the second in July to August (Fig.1). However apart from organic matter, we also evaluated the quantity of TAM suspended in the water column. This component had the same course as the organic component (Fig.1). Both components reach an equal proportion in balanced river ecosystems. In this section of the Turiec we found that the average value of the TAM component exceeded the organic component transported by the flowing water by almost four times, thanks to the extremely high
values in July. The large increase of anorganic material in the summer period, was unnatural and directly connected with the preparatory ground work in the basin.

![Graph showing seasonal dynamics of transport organic (TOM) and anorganic (TAM) matter](image)

**Fig. 1** Seasonal dynamics of transport organic (TOM) and anorganic (TAM) matter (Turiec Sklené, years 1992-1993)

The seasonal dynamics of periphyton had two peaks during the year (Fig.2): in spring (April) and in autumn (September to December). A low quantity of periphyton occurred in July, that is in the period when the highest values for transported anorganic material occurred. We found that a negative exponential dependence exists between the biomass of TAM and the biomass of periphyton. One of the explanations of this fact is the mechanical action of TAM on periphyton as well as their siltation. The average quantity of periphyton compared to the previous period was essentially unchanged, but the quantity of moss in the stream substantially declined.

![Graph showing seasonal dynamics of periphyton biomass](image)

**Fig. 2** Seasonal dynamics of periphyton biomass (Turiec Sklené, years 1992 - 1993)

The quantity of coarse benthic organic matter (CBOM, Tab.1) increased as a result of erosion. We recorded the highest values for BOM on a gravel-sand substratum.
**TABLE 1** Characteristics of some average data for basic factors of the river Turiec (Sklené).

<table>
<thead>
<tr>
<th>Years</th>
<th>1987-88</th>
<th>1992-93</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient of stream (slope in %)</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Discharge (m$^3$.s$^{-1}$)</td>
<td>0.60</td>
<td>0.81</td>
</tr>
<tr>
<td>Stream order</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Stream link magnitude</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Max. temperature (°C)</td>
<td>17.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Oxygen (mg l$^{-1}$)</td>
<td>9.77</td>
<td>11.20</td>
</tr>
<tr>
<td>BOD 5 (mg l$^{-1}$)</td>
<td>1.99</td>
<td>2.29</td>
</tr>
<tr>
<td>NO$_3^-$ (mg l$^{-1}$)</td>
<td>3.94</td>
<td>3.39</td>
</tr>
<tr>
<td>NH$_4^+$ (mg l$^{-1}$)</td>
<td>0.20</td>
<td>0.22</td>
</tr>
<tr>
<td>PO$_4$$^{3-}$ (mg l$^{-1}$)</td>
<td>0.161</td>
<td></td>
</tr>
<tr>
<td>Ca$^{2+}$ (mg l$^{-1}$)</td>
<td>18.70</td>
<td>18.09</td>
</tr>
<tr>
<td>pH</td>
<td>7.08</td>
<td>7.23</td>
</tr>
<tr>
<td>CBOM (gm$^{-2}$.AFDM)</td>
<td>18.90</td>
<td>30.40</td>
</tr>
<tr>
<td>FBOM (gm$^{-2}$.AFDM)</td>
<td>-</td>
<td>336.70</td>
</tr>
<tr>
<td>UBOM (gm$^{-2}$.AFDM)</td>
<td>-</td>
<td>142.00</td>
</tr>
<tr>
<td>TAM (gm$^{-3}$)</td>
<td>-</td>
<td>38.50</td>
</tr>
<tr>
<td>TOM (gm$^{-3}$.AFDM)</td>
<td>-</td>
<td>10.80</td>
</tr>
<tr>
<td>Periphyton (gm$^{-2}$.AFDM)</td>
<td>6.63</td>
<td>8.20</td>
</tr>
<tr>
<td>Macrophytes (gm$^{-2}$.AFDM)</td>
<td>1.98</td>
<td>0.00</td>
</tr>
<tr>
<td>Saprobity index</td>
<td>0.89</td>
<td>1.04</td>
</tr>
</tbody>
</table>

This is connected with its increased sedimentation in sections of the stream with a smaller flow of water. The greatest variation in the quantity of deposited detritus also occurs here, although the bottom is less stable. In contrast to a bottom covered by rocks, a gravel-sand bottom is associated with an increased speed of flow, which disturbs and removes detritus during periods of high water in the stream. We recorded the highest flow in March. With gradual lowering of the flow, the quantity of fine benthic organic matter (FBOM) and ultrafine benthic organic matter (UFBOM) on the gravel-sand substratum increased (Fig. 3). In the months of July to September, FBOM and UFBOM suddenly decreased in spite of the low flow, as a result of their rapid breakdown thanks to the high temperature of the water. On a more stable rocky substratum,
the quantity of FBOM was more even, while the quantity of UFBOM underwent greater variations (Fig.4).

Fig. 4 Seasonal dynamics of detritus and wood matter in stones substratum (Turiec Sklené)

**Microzoobenthos.** Among microzoobenthos, Ciliophora are one of the best indicators of changes in water quality. On a rocky substratum the following species of Ciliophora were dominant: Aspidisca lycceus, Trochilia minuta, Chilodonella uncinata, on a gravel sand substratum: Cinetochilum margaritaceum, Trithigmostoma cucullus, Acineria uncinata. The influence of strong erosion was probably indicated on a sand-detritus substratum, where increased sedimentation occurred, and so also a concentration of break down processes on this substratum. This caused changes in the course of the curves of seasonal dynamics (Fig.5). Revival on a substratum of plants is

Fig. 5 Seasonal dynamics of abundance of ciliated protozoa (Ciliophora) in different substrate types (Turiec Sklené, years 1992-1993)

dependent on the physiological state of the plants. The substratum of rocks was least influenced by erosion, and preserves the classic parameters of seasonal dynamics
(spring and autumn maxima). The average annual abundance of Ciliophora increased by roughly two times at the given locality. The proportion of other components of the microzoobenthos (Amoeboidea, Rotatoria, Nematoda) increased in dependence on the substratum and season, which is also associated with an increased supply of alocthonous material. Compared to the preceding period, the number of identified species of Ciliophora increased from 45 to 65. We identified 5 new species of Ciliophora for the fauna of the Turiec basin: *Cothurnia imberbis, Lacrymaria nana, Litonotus mononucleatus, Enchelyodon elegans, E. farcitus.* However, it was especially the abundance of the euryoecious taxa that increased. The trophic structure of the Ciliophora also changed moderately (Fig. 6). The proportion of omnivore species increased at the expense of the carnivores. This is probably also connected with the supply of alocthonous material. The proportion of bacteriovorous species increased only slightly.

![Diagram](image)

**Fig. 6** Trophic structure of the ciliated protozoa (Ciliophora) in original status (a) and after beginning of constructions drinking water reservoir (b)

**Macrozoobenthos.** The new species for the fauna of the Turiec basin are: *Ameletus inopinatus, Baetis vardarensis, Rhithrogena podhalensis, R. savoiensis, Rhyacophila mocsaryi.* Absence of the Perlidae family, representatives of which are sensitive to significant variations of flow, as well as occasional occurrence of species *Ameletus inopinatus, Rhithrogena podhalensis* and *Rhyacophila mocsaryi* associated with the Carpathian Mountain complex, indicate a different character of the biotope in the past. The negative influence of the Turček water pipe (significant removal of water from the basin) causes the absence of rheophil, cold loving, mountain and sub-mountain forms requiring a greater flow throughout the year.

On a rocky substratum, the following taxa of macrozoobenthos are dominant: *Dugesia gonocephala, Stylodrilus heringianus, Ancylus fluviatilis, Baetis rhodani, Rhithrogena ferruginea, Ephemera mucronata, Nemoura uncinata, Leuctra hippopus, Hydropsycha saxonica, Ecclisopteryx dalecarlica, Limnius perrisi, Elmis aenea, E. maugetti, Dicranota sp., Ibisia marginata, Atherix ibis, Prosimulium hirtipes,* and on a gravel-sand substratum *Pisidium sp., Caenis heskidiensis, Nemoura flexuosa, Ecclisopteryx delacarlica, Annitella obscurata, Sericostoma sp., Oreozytes sanmarki, Limnius perrisi, Eloephila submarmorata, E. maculata, E. mundata* are dominant.
Influence of the construction of reservoir

*Hiripes*, and on a gravel-sand substratum *Pisidium* sp., *Caenis beskidensis*, *Nemoura flexuosa*, *Eccisopteryx delacarlca*, *Aninella obscurata*, *Sericostoma* sp., *Oreodytes sanmarkii*, *Limnius perrisi*, *Eloeophila submarmorata*, *E. maculata*, *E. mundata* are dominant. Comparison of some parameters of species diversity and abundance of these groups of macrozoobenthos (Tab.2) in two different time periods showed a very striking decline in the majority of these values in the years 1992-1993.

**Table 2** Number of species (S), diversity (H), evenness (E), and abundance (A) in ind.m^{-2} of the chosen groups of macrozoobenthos in the river Turiec (Sklené).

<table>
<thead>
<tr>
<th>Years</th>
<th>Taxonomic groups</th>
<th>S</th>
<th>H</th>
<th>E</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td><em>Ephemeroptera</em></td>
<td>23</td>
<td>2.67</td>
<td>0.80</td>
<td>1343</td>
</tr>
<tr>
<td>1992-93</td>
<td><em>Ephemeroptera</em></td>
<td>29</td>
<td>1.64</td>
<td>0.69</td>
<td>368</td>
</tr>
<tr>
<td>1987-88</td>
<td><em>Plecoptera</em></td>
<td>28</td>
<td>1.61</td>
<td>0.76</td>
<td>337</td>
</tr>
<tr>
<td>1992-93</td>
<td><em>Plecoptera</em></td>
<td>16</td>
<td>0.86</td>
<td>0.60</td>
<td>231</td>
</tr>
<tr>
<td>1987-88</td>
<td><em>Trichoptera</em></td>
<td>16</td>
<td>1.47</td>
<td>0.70</td>
<td>927</td>
</tr>
<tr>
<td>1992-93</td>
<td><em>Trichoptera</em></td>
<td>18</td>
<td>1.49</td>
<td>0.66</td>
<td>394</td>
</tr>
<tr>
<td>1987-88</td>
<td>other <em>Diptera</em></td>
<td>17</td>
<td>1.77</td>
<td>0.69</td>
<td>141</td>
</tr>
<tr>
<td>1992-93</td>
<td>other <em>Diptera</em></td>
<td>15</td>
<td>0.97</td>
<td>0.39</td>
<td>41</td>
</tr>
</tbody>
</table>

We found the lowest diversity and biomass in the summer period, which is very unnatural, since it is precisely in this period that diversity reaches its peak in these types of habitats. In species composition, the disappearance of many species of zoobenthos is striking. The significant decline in the abundance of the following taxa occurs: *Ephemarella major*, *Caenis beskidensis*, *Amphinemura sulcicollis*, *Isoperla oxylepis*, *Perlodis microcephalus*, *Rhyacophila tristis*, *Glossosoma conformis*, *Hydropsyche instabilis*, *Eccisopteryx madida*, *Ibisia marginata* and *Atherix ibis*. On the other hand new species appear and the number of euryoecious taxa such as: *Nemoura flexuosa*, *N. uncinata*, *Baeatis fuscatus*, *Centroptilum luteolum*, *Habroleptoides modesta*, *Hydropsyche saxonica*, *Aninella obscurata*, *Sericostoma* sp., *Limnius perrisi* significantly increases. A significant decline in the proportion of collectors occurs in the trophic structure of the macrozoobenthos (Fig. 7). Increased sedimentation and colmatation of interstitial spaces causes this (MILNER et al. 1981, RIVIER and SEQUIER 1985). In the conditions of the upper Turiec, this manifests itself in a decrease in detritophages (Tab. 3) (*Oligochaeta*, *Nemuroidea*, *Chironomidae*), which form the most significant part of the interstitial fauna. Similarly there was also a decline in the proportion of scrapers. This fact appears above all in the decline of the absolute values of this trophic group (from 1200 to 668 ind.m^{-2}). A similar decline of the absolute values for predators (320 - 200 ind.m^{-2}) occurs as a result of the decline of their natural food (decline of the abundance of macrozoobenthos by 1/3 from 3091 to 1913 ex.m^{-2}). On the other hand, we recorded a significant increase of filtrators, which is caused by increased transport of TOM. The production of the trophic groups of the macrozoobenthos of the Turiec river is
TABLE 3 Annual production of macrozoobenthos in g.m\(^{-2}\) dry weight of the Turiec river (Sklené)

<table>
<thead>
<tr>
<th>Taxonomic group</th>
<th>Production</th>
<th>Annual P/B</th>
<th>Taxonomic group</th>
<th>Production</th>
<th>Annual P/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbellaria(^1)</td>
<td>0.34</td>
<td>8.1</td>
<td>Ephemeroptera</td>
<td>1.00</td>
<td>7.5</td>
</tr>
<tr>
<td>Gastropoda(^1)</td>
<td>0.13</td>
<td>3.3</td>
<td>Plecoptera</td>
<td>0.41</td>
<td>7.6</td>
</tr>
<tr>
<td>Bivalvia(^1)</td>
<td>0.04</td>
<td>3.5</td>
<td>Coleoptera</td>
<td>0.40</td>
<td>1.6</td>
</tr>
<tr>
<td>Oligochaeta(^1)</td>
<td>0.10</td>
<td>7.0</td>
<td>Trichoptera</td>
<td>2.79</td>
<td>3.6</td>
</tr>
<tr>
<td>Hirudinea(^1)</td>
<td>0.04</td>
<td>3.5</td>
<td>Chironomidae</td>
<td>0.61</td>
<td>18.7</td>
</tr>
<tr>
<td>Amphipoda</td>
<td>0.38</td>
<td>5.4</td>
<td>Simuliidae</td>
<td>0.41</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7.24</strong></td>
<td><strong>4.2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) - according KRNO et al. 1994

Significantly conditioned by flow, temperature regime, erosion, quantity and quality of food. In the upper course of the Turiec river a worse flow and erosional effects significantly deteriorated the ecological effectiveness of this hydrocoenoses (Tab. 4). The significantly higher proportion of alder leaves (1:1 - willow and alder) positively influences the moderately increased proportion of consumed CBOM in the upper course. The higher consumption of macrozoobenthos by predators shows a lower predation pressure from fish. The proportion of production of macrozoobenthos consuming periphyton towards detritophages reaches only 0.6:1 in the upper course. This does not correspond to the position of this locality in the concept of the river continuum (the original proportion was close to 1). The theoretically suggested P/B coefficient derived from abiotic factors (STATZNER, 1987) is significantly lower than the real one (6.1 resp. 4.2).

TABLE 4 Percentual ratio between consumption of trophic guilds of macrozoobenthos and quantity of food according KRNO et al. (1994) and Tab. 3 in different sections of the Turiec river.

<table>
<thead>
<tr>
<th>Sampling sites</th>
<th>Years</th>
<th>Habitat</th>
<th>Scrapers</th>
<th>Shredders</th>
<th>Collectors</th>
<th>Filterers</th>
<th>Predators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turiec river (Košťany)</td>
<td>1987-1988</td>
<td>hyporhithral</td>
<td>1.7</td>
<td>12.7</td>
<td>5.4</td>
<td>1786</td>
<td>26.9</td>
</tr>
<tr>
<td>Turiec river (Sklené)</td>
<td>1992-1993</td>
<td>metarhithral</td>
<td>0.5</td>
<td>15.9</td>
<td>0.9</td>
<td>272</td>
<td>35.1</td>
</tr>
</tbody>
</table>
Fig. 7. Trophic structure of the macrozoobenthos in original status (a) and after beginning of construction drinking water reservoir (b)

ACKNOWLEDGMENT

We thank to dr. Bitušík, dr. Halgoš and dr. Kodada for determination of Chironomidae, Simuliidae and Coleoptera.

REFERENCES


