Plankton communities of the transboundary Ukrainian-Romanian section of the Tisa River

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1 Introduction

Carpathian rivers are considered the most undisturbed and clean rivers in Ukraine. However, recently floods became more frequent in the Carpathians. They disturb banks of the rivers, ruin soils, and negatively affect biological diversity. Erosion of slopes worsens water-retaining ability of soils, disturbs evolutionary formed benthic and planktonic communities. Anthropogenic impact also causes damage on the river biota. Apart from hydromorphological alteration (partial banks reinforcement) the most negative is discharge of insufficiently treated industrial and municipal waste waters, accumulation of municipal litter and wood decay products of the timber-cutting industry in the river basins. Therefore, study and monitoring of the mountainous rivers are of essential importance. Results of such investigation enable to assess character and rate of the biota's response to these impacts.

Planktonic communities of the transboundary Ukrainian-Romanian section of the Tisa River Basin were studied in view of activities connected with assessment of ecological status of the water bodies and search of the reference sites according to the WFD principles. Though neither phytoplankton, nor zooplankton are recommended as quality elements for mountainous rivers, they are an important component of the aquatic ecosystems. They are closely connected by trophic relations with each other and with other biotic components (first of all with fish).

The Tisa River is the largest tributary of the Danube. Its length is 966 km (within Ukraine – 201 km), the catchment area 157 000 km² (within Ukraine – 11 300 km²). It starts at the Chorna and Bila Tisa rivers confluence, 4 km upstream of Rakhiv. Along 64 km (from Dilove to Tiachiv) it forms the state boundary between Ukraine and Romania. At this section it is a typical mountainous river with stony or gravel bed. Its peculiarity is a considerable fluctuation of environmental conditions, caused by dynamic discharge between floods and low water. Average velocity of flow amounts to 2–4 m/s. The river carries extremely high content of suspended matter due to erosive soils in the catchment. High turbidity negatively affects development of planktonic communities.

The aim of the study was to compare the present situation with the scarce data of earlier records that are significantly fewer in the upper river sections, and to document the changes of biological diversity.

2 Methods

In 2009 phytoplankton and zooplankton of the main channel (sites 1–3) and mouth areas of the main tributaries – the right-bank Kisva, Shopurka, Apshytsia, Teresva (sites 4–7) and the left-bank – Iza, Vişeu and Săpânța (sites 8–10) have been investigated. Phytoplankton samples were taken by filling of 0.5 l glass vessels. For zooplankton sampling 300 l of water were filtered using the plankton Apstein net №64. Samples were conserved by formaldehyde solution. Organisms were identified and counted using light microscope Carl Zeiss Primo Star. Numbers and biomass were calculated according to standard hydrobiological methods (Romanenko, 2006).

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3 Results

Phytoplankton of the studied section comprised in total 65 algal species of 4 departments; Bacillariophyta prevailed (61 species). On average their numerical density and biomass amounted to 98% and 99% of the total, respectively. Representatives of class Centrophycea were almost absent. It is worth noting that the significant portion was formed by periphytic forms: *Didymosphenia geminata* (Lyngb.) M.Schmidt, *Ceratoneis arcus* (Ehr.) Kütz. and species of the genera *Gomphonema* and *Rhoicosphaenia.* Species of other departments occurred sporadically (Euglenophyta – 2 species, Cryptophyta – 1 species and Chlorophyta – 1 species).

In the Tisa River 30 species were found, among them 29 of Bacillariophyta. Average numerical density amounted to 904 000 cells/l, average biomass to 1.48 mg/l. Along the studied section differences in phytoplankton species richness and quantitative characteristics were of minor importance (Figure 1). The most abundant taxa were *Achnanthidium minutissimum* Kütz. (15.7% of the total), *Gomphonema longiceps* Ehr. (10.1%), *Navicula cryptocephala* Kütz. (9.7%); in terms of biomass prevailed *Didymosphenia geminata* (42.8% of the total). It is worth noting that because of significant individual biomass this species dominated practically at all sites, even if its abundance was low.

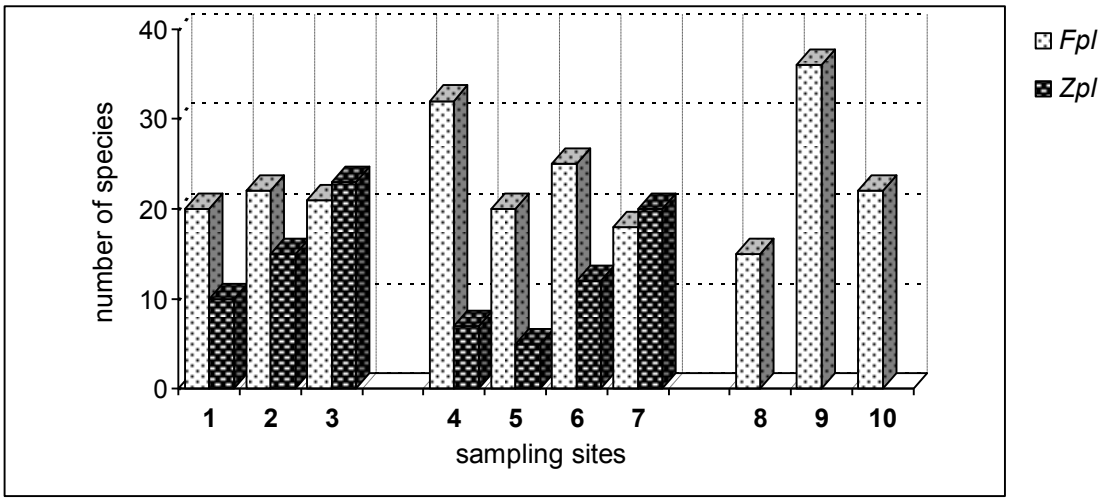

Figure 1. *Number of phytoplankton (Fpl) and zooplankton (Zpl) species. (Sites number as in the text).*

Phytoplankton in the mouth areas of tributaries was more diverse and abundant than in the main channel. Totally 61 algal species were found. Many species occurred in all tributaries; however, every tributary had its peculiar dominant species in terms of numbers (as mentioned above, *Didymosphenia geminata* dominated by biomass practically at all sites, except the Vişeu River, where it was not found at all). Also tributaries differed by quantitative characteristics. The lowest species richness, numbers and biomass were registered in the Vişeu River, where *Achnanthes minutissima* and *Gomphonema parvulum* (Kütz.) Grun. (23.9 and 10.9% of total numbers, respectively) were most abundant; in terms of biomass prevailed *Synedra ulna* (Nitzsch) Ehr. and *Cocconeis placentula* Ehr. (19.1 and 12.9% of total, respectively).

Maximum species richness was noted in the Iza River. Just here algae of four departments were found. The most abundant were *Achnanthidium minutissimum* and *Gomphonema longiceps* (13.2 and 8.5% of total, respectively); in terms of biomass prevailed *Didymosphenia geminata* (26.3%).

Maximal phytoplankton density was observed in the mouth area of the Kisva River – 2162 500 cells/l. The most abundant was *Gomphonema longiceps* (12.1% of total), in terms of biomass prevailed *Didymosphenia geminata* (50.9% of total). Maximal phytoplankton biomass was noted in the mouth area of the Teresva River; where biomass of *Didymosphenia geminata* amounted to 82.1% of total. Probably, peculiarities of hydrological regime of the Teresva River caused washing the cells off the substrata. It is also worth noting the interesting fact that just in this river phytoplankton samples contained microscopic thalloms of the cryophilic alga *Hydrurus foetidus* (Vill.) Kirchn. (Chrysophyta) of

the early development stage (they were not accounted as phytoplankton). Its occurrence can probably indicate xenosaprobic conditions in the Teresva headwater. This alga is considered as indicator of reference conditions for mountainous Carpathian rivers (Afanasyev, 2006).

In the Sapintsa River intensive development of *Ceratoneis arcus* was observed (23.0% of total numbers and 17.7% of total biomass). Because of this fact it is possible to assume oligosaprobic conditions in the headwater of Sapintsa.

Thus, phytoplankton of the studied sections is quite diverse. Notable contribution into the species richness was formed due to periphytic and benthic forms, which were detached from the hard substrata. Large-cell forms contributed to the biomass which is peculiar for mountainous rivers.

Zooplankton of the studied section of the Tisa River (except the left-bank tributaries, which were not studied) comprised 47 taxa, among them 28 rotifers (Rotatoria), 9 Copepoda (Cyclopoida, Calanoida and Harpacticoida) and 10 Cladocera. Most of taxa were found in summer. Zooplankton species richness increased along the Tisa channel. At the site nearby Dilove only 10 taxa were found, and at the downstream site (nearby Tiachiv) 23 taxa were registered. Species number in the tributaries Kisva, Apshytsia and Teresva did not exceed 10 taxa, and in the Shopurka River only bottom forms of invertebrates were found (Fig. 1).

Rotatoria showed highest species richness. In the upper sections occurred only single specimens of Cladocera. Their number increased downstream. Copepoda were the most widely distributed group, they occurred at all studied sites. The most abundant were rotifers *Euchlanis dilatata dilatata* Ehrenberg (frequency of occurrence 62–86%), which are common for periphyton, and Cladocera *Bosmina longirostris* O.F. Müller and *Chydorus sphaericus* (O.F. Müller). These species and rotifers *Polyarthra vulgaris* Carlin, *Brachionus calyciflorus* Pallas, *Keratella cochlearis* (Gosse), *K. quadrata* Müller, Cyclopoida *Cyclops strenuus* Fischer, *C. vicinus* Uljanin, *Acanthocyclops vernalis* (Fischer), Cladocera *Daphnia longispina* O.F. Müller, *Moina rectirostris* Hellich are characteristic for the zooplankton of the Tisa Basin. On the whole at this section prevailed rheophilic invertebrates: Harpacticoida, rotifers *Cephalodella* sp., nonloricate rotifers of the family Philodinidae and Cladocera *Chydorus sphaericus*. In spring and summer rotifers and Cyclopoida prevailed, and in autumn Cyclopoida and Cladocera.

Significant amounts of drifted bottom invertebrates were also found in zooplankton samples. This is common for most mountainous rivers as caused by high velocity and turbulence of flow, especially in the highland sections. The most abundant macroinvertebrates were Oligochaeta, Nematoda, larvae of Chironomidae, Plecoptera, and Ephemeroptera.

Zooplankton of the studied section was scarce, depending mainly on the drift intensity (200–2700 specimens/m^3; biomass 0.01–0.03 g/m^3). Its composition and abundance varied within wide limits dependent on the discharge regime and water level. At the site nearby Dilove species composition was enriched due to forms associated with substrata (*Chydorus sphaericus* of Cladocera, *Paracyclops fimbriatus* Copepoda*, Harpacticoida* sp. etc.). In the studied tributaries zooplankton was less abundant than in the main channel, except of the Teresva River, where its numbers amounted to 20–470 specimens/m^3 and biomass to 0.01–0.02 g/m^3. These values are characteristic for the upper section of the Tisa River (Polischuk & Garasevych, 1986; Kharchenko et.al., 2003).

Thus, zooplankton of the transboundary section of the Tisa River was represented by few taxa and was not abundant though increasing downstream. Prevailing forms were associated with substrata and drifting bottom invertebrates.

4 Discussion and summary

At present biota of the mountainous rivers and their planktonic sub-system occur under disturbed ecological balance, conditioned by anthropogenic impact (unregulated construction of roads, power-lines, intensive agriculture and forest harvesting). Disturbance of the biota's habitats stability is undesirable as it diminishes species diversity. The risk of structural degradation drastically grows (decrease of species number, up to the elimination of whole systematic groups; significant fluctuations of number and biomass of some species, disturbance of the stable community structure etc.). Unfortunately, such signs are observed in the Upper Tisa Basin. Thus, a long-term tendency of decreasing zooplankton species richness was observed. At the end of the 1960s zooplankton of the

Upper Tisa comprised 126 taxa of aquatic invertebrates (Polishchuk et al., 1986). Later this list was reduced four times (Zsuga, 1999; Kharchenko et.al., 2003). We have found 47 taxa of invertebrates. According to literature data diversity of ichthyofauna also decreased (Natural resources…, 1987; Kharchenko et.al., 2003). Such tendency was not evident for phytoplankton (Hamar, 1999), which may be explained by beginning eutrophication contributing to the primary producers' development.

Different zooplankton (consumers) and phytoplankton (primary producers) development may be explained by their different response to changes of hydrological conditions (reduced flow velocity).

Planktonic communities of all rivers in the Tisa River Basin need further regular studies in order to reveal long-term tendencies and to assess the water bodies' ecological status.

Individual findings of the rare hydrobionts species (macroscopic alga *Hydrurus foetidus* of Chrysophyta, *Mixodiaptomus tatricus* (Wierz.) and *Macrocyclops distinctus* (Rich.) of Copepoda) in the studied rivers indicated the significance and originality of this area.

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