Actual state of biota of the Beregove transboundary polder system as instrument for its ecological status/ potential assessment

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Keywords: biological quality elements, ecological status/potential, polder system, the Tisa River

1 Introduction

Catastrophic floods were recorded in the Ukrainian Carpathians in recent years. These perturbations demonstrated the urgent need to bring into play available infrastructure of hydrotechnical constructions, amelioration channels and polders, and further to use them in flood-control measures. The polder systems in the Transcarpathian region have been constructed more than a century ago. They became a unique biodiversity refuge for decades and need therefore to be protected as wetland areas.

The Beregove transboundary polder system (BTPS) is an amelioration system located in the basins of the Tysa and Latoritsa Rivers shared by two countries – Hungary and Ukraine. The total area of BTPS amounts to 880 km^2, where 60% are in Ukraine (Transcarpathian region) (National atlas…, 2007). Hydrotechnical activities have begun in the second half of the 19th century. Up to the mid 1950s BTPS consisted mainly of wetland ecosystems that were almost unsuitable for agricultural use. In the end of the 1950s wide-scale amelioration caused crosscut of almost all areas by a channels net. Hence, the natural features of the floodplain have been lost. However, most agricultural areas are not developed, and many sections of the polder system do not function. Therefore renaturalization dealt with biocoenoses, and existing melioration channels were not cleaned and dredged; they became sites of excessive aquatic and riparian vegetation. Lakes feature minor water exchange and are fed from the limited watershed, during floods and by groundwater infiltration. Washout of the organic fertilizers from the adjacent agricultural areas and high air and water temperatures in summer contribute to an intensive eutrophication of the water bodies.

BTPS comprises the main channel Charonda-Latoritsa (5 km long) and channels of the second (Charonda-Tysa, Sypa-Charonda) and third order (Lower-Sernyanskiy and Upper-Sernyanskiy), constructed in the large-scale amelioration activities. It also includes some rivers and lakes – former riverbeds, which were isolated from the main channels "naturally", before construction activities have been started. In periods between floods the water from the system flows into the Tysa and Latoritsa Rivers by gravity. During the floods, when water level in the rivers is higher than in the channels, locks in the rivers are closed and excess water from the system is removed by stationary and if needed by mobile pumping stations.

At present the most urgent problem in BTPS is clearance and rehabilitation of the channels in order to provide more effective flood protection of the settlements, industrial objects and agricultural land and water supply during droughts. This often arises a conflict of interests. On the one side it is necessary to ensure good ecological status and ecological potential of the water bodies. On the other side, a mechanical maintenance of the channel system is required but would destroy the habitats of the rare, valuable and protected plant and animal species and therefore not contribute to protect and enhance biological diversity.

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The aim of this work was to study the actual state of biota of different-type water bodies of the BTPS in order to assess their ecological status/potential.

2 Methods

Hydrobiological measurements in the BTPS were carried out during 2009. Further we evaluated literature data from 1999, 2000 and 2005 (Afanasyev 2002, 2006). We analyzed phytoplankton, aquatic plants, zooplankton, bottom invertebrates, and ichthyofauna. The bottom invertebrate fauna was studied in most detail as it is the main indicative group used in water quality and ecological status assessment.

Sampling and sample processing were carried out according to standard hydrobiological methods (Romanenko, 2006). Further, we were taking into account the specific character of mountainous rivers and applied specific methods by Afanasyev (2006) and standard EC methods (AQUEM) (http://www.eugris.info/). Assessment of the River Tisa ecological status was carried out according to the Water Framework Directive 2000/60/EC, on the basis of the RQBA (River Quality Biological Assessment) methods developed in Ukraine (Afanasyev 2002, 2006).

3 Results

The water bodies of BTPS are at different stages of biological successions. It is mirrored by its vegetation character, dependent on their genesis and exploitation, the plankton and benthos development and the occurrence of certain fish species. The main characteristics of biotic communities in the considered water bodies are as follows.

Phytoplankton 126 algae species of 7 departments were found. During the investigation period. The most diverse algal group were Bacillariophyta (53 species). They were followed by Euglenophyta and Chlorophyta (26 species each). Other departments comprised: Cyanophyta and Chrysophyta – 8 each, Cryptophyta – 4, and Dinophyta – 1 species. Maximum number of species comprised genera *Nitzschia* (10), *Euglena* and *Navicula* (9 each), *Trachelomonas* and *Synedra* (6 each). Common forms for periphyton taxa were *Cymbella*, *Gomphonema* etc. Species richness increased from spring (51 species) to summer (70 species) and autumn (79 species). In all seasons Euglenophyta were more diverse and abundant than Chlorophyta. This indicates the presence of easily-accessible dissolved organic matter. The most species rich habitat was channel Charonda-Tysa (92 species), while the lowest species richness was found in the Upper-Sernyanskiy channel (12).

Aquatic plants. By general features of vegetation, BTPS encompasses the European broad-leaved zone, Middle-European province and Pannonia sub-province. The main landscape type is agrocenosis in combination with floodplains, wet and dry meadows, willow beds and poplar thickets. Some limited areas remained primary wetland complexes. According to our observations, 23 species of aquatic macrophytes were found in BTPS. Among them 9 helophytes, 4 – plants with floating leaves, 6 – submerged plants and 1 species of filamentous algae. Some species recorded here are rare and found in the reference list of the Red Book of Ukraine: *Salvinia natans* L. All., *Trapa natans* L., *Nymphoides peltatae* (S.G. Gmel.) O. Kuntzee. Some species need additional protection and are included into the UICN list or protected under the Bern Convention.

Zooplankton. Observed zooplankton communities comprised 71 species, among them Rotatoria – 31, Copepoda – 14 (including nauplial and copepodite stages), and Cladocera – 26 species. In general, the zooplankton was low in abundance. Mass species were those associated with eutrophic and meso-saprobic conditions. Concerning the feeding type they were mainly euryphagous (for instance, rotifer *Asplanchna priodonta* Gosse, juvenile Copepoda) and detritophagous (rotifers of the order Bdelloida, some species of family Chydoridae). The trophic structure of the zooplankton community was quite diverse: both primary consumers (most of rotifers, Copepoda stad. nauplius et stad. copepodit I–III, and Cladocera), and secondary consumers (mature Cyclopidae). Maximum numbers and biomass were observed in autumn in the channels (93,000 specimens/m^3, biomass 1.00 g/m^3). The most abundant species belonged to the family of Cyclopidae. High Crustacean numbers and biomass were also noted in summer in the dead channel Charonda due to favorable conditions. In the channels Rotatoria and Copepoda prevailed, while Copepoda and Cladocera dominated in the former riverbed. Species composition of zooplankton was quite stable throughout seasons.

Macroinvertebrates. Macroinvertebrates comprised 82 species in the bottom sediments. In total 124 species were found, including periphytic forms and species associated with higher aquatic plants (18 taxonomic groups). Chironomidae larvae were the most diverse – 43 species. They were followed by Molluska (Gastropoda – 28 and Bivalvia – 4 species). Other taxonomic groups were significantly less diverse as Oligochaeta – 5, Hirudinea – 3, Isopoda – 3, and Gammaridae – 1 species. Besides Chironomidae larvae, among Insecta were found Trichoptera larvae – 8, Diptera larvae – 7, Odonata larvae – 4, Heteroptera and Coleoptera – 2 each, Culicidae – 1, Ephemeroptera nymphae – 7, and Plecoptera nymphae – 1 species. Maximum species richness was noted in the Charonda-Latoritsa channel (46 species). Somewhat less (about 40 species) richness was found in the Charonda-Tysa and Upper-Sernianskiy channels and former riverbed Charonda. Minimum species richness was noted in the drying channel Charonda-Sypa (only 8 species), which featured also minimum abundance: only Oligochaetes were found (density less than 100 specimen/m^2). In all channels density and biomass of macroinvertebrates varied within wide limits, most likely due to seasonal dynamics of aquatic vegetation. Thus, in the Charonda-Latorytsia channel macroinvertebrates in summer amounted to 1600 specimen/m^2, while in autumn, when plants were bent to the bottom, the number increased to 3800 specimen/m^2.

Ichthyofauna. In the water bodies of BTPS 15 fish species of 6 families were found. Among them Cyprinidae: *Scardinius erythrophthalmus* (Linnaeus, 1758), *Carassius auratus gibelio* (Bloch, 1782), *Rutilus rutilus* (Linnaeus, 1758), *Abramis brama* (Linnaeus,1758), *Leuciscus cephalus* (Linnaeus,1758), *Abramis sapa* (Pallas, 1814), *Leuciscus idus* (Linnaeus, 1758), *Abramis ballerus* (Linnaeus, 1758), *Aspius aspius* (Linnaeus, 1758), *Chondrostoma nasus* (Linnaeus, 1758); Ictaluridae: *Ictalurus nebulosus* (Le Sueur, 1919); Esocidae: *Esox lucius* (Linnaeus, 1758); Percidae: *Perca fluviatilis* (Linnaeus, 1758); Odontobutidae: *Perccottus glenii* (Dybowski,1877); Centrarchidae: *Lepomis gibbosus* (Linnaeus, 1758). In the catches dominated *Rutilus rutilus, Scardinius erythrophthalmus, Ictalurus nebulosus.* In the considered water bodies four invasive fish species were found (*Perccottus glenii*, *Ictalurus nebulosus, Lepomis gibbosus* and *Carassius auratus gibelio*). Not any species of the Red book of Ukraine was noted. In the Charonda-Tysa channel 14 fish species were caught, in the Charonda-Latoritsa channel – 9, in the Charonda former riverbed – 5. Such distribution was driven by the oxygen regime in the water bodies of BTPS. The technical regulation of the channels may be favorable to disperse invasive fish species into other water bodies of the Tysa River Basin.

4 Discussion

In general, the hydrobiological studies of the BTPS water bodies showed a pronounced development of biota and high biological diversity of the aquatic organisms. Primary assessment of the habitats and general features of the biotic communities were used for the further assessment of the ecological status of the water bodies. Such analysis was carried out on the basis of “field protocols” and sample processing (Afanasyev, 2006). Hydrobiological studies were directed to the determination of the actual status of water bodies in BTPS and a general ecological analysis of the region. This enabled to establish type-specific characteristics of the biological quality elements for each water body in terms of water quality, benthos community structure and biodiversity. The biological reference conditions for the water bodies of BTPS were established as shown in Table 1.

Table 1. *Reference biological parameters for different types of natural water objects BTPS*

Characteristics	Rivers		Lakes	
	Small lowland rivers, siliceous geology	Medium sized lowland rivers, siliceous geology	Dead channels with hydraulic connection	Totally isolated dead channels (former riverbeds)
BLOCK 1 – Water quality (bioindication of water quality)				
Trent Biotic Index (TBI)	*7*	*7*	*8*	*6*
Saprobity, phytoplankton,	*1.6*	*1.6*	*1.7*	*1.8*

zooplankton				
Trophic state	mesotrophic	mesotrophic	mesotrophic	eutrophic
BLOCK 2 – Structure of bottom invertebrates communities (*groups indicative and specific for reference conditions*)				
Species number	*Plecoptera >1 Ephemeroptera – 4* *Trichoptera – 4* *Odonata – 3* *Gastropoda – 5*	*Plecoptera – 2* *Ephemeroptera – 5;* *Trichoptera – 5* *Odonata – 3* *Bivalvia – 1* *Gastropoda – 7*	*Plecoptera >1* *Ephemeroptera – 4* *Trichoptera – 3* *Odonata – 3* *Bivalvia – 1* *Gastropoda – 7*	*Ephemeroptera – 3* *Trichoptera – 5* *Odonata – 5* *Gastropoda – 5*
BLOCK 3 – Biodiversity *(indicative and specific for reference conditions, endemics and protected species)*				
Rare and protected plant and animal species	*8*	*10*	*10*	*12*
Native fish species	*6*	*10*	*3*	*2*
Invasive fish species	*no*	*no*	*no*	*no*

Then, on the basis of the obtained data RQBA tables were completed (Afanasyev, 2001). The assessment was carried out by comparison of characteristics in the columns „actual status" and „target status" (i.e. reference conditions) using the following classification: 0-5% deviation from the reference means "high status", 5–35% deviation means "good status", 35-65% deviation means "moderate status", 65-95% deviation means "poor status", and 95-100% deviation means "bad status" (Afanasyev, 2006). Furthermore, the general assessment includes unpublished data observed by Prof. O. Obodovskiy, Dr. O. Yaroshevich, and Dr. O. Konovalenko on hydromorphological assessment, and by ing. Eduard Osiyskiy on hydrochemical assessment. Table 2 provides the ecological status/potential of the water bodies of BTPS.

Table 2. *Classification of the ecological status/potential of the water bodies of BTPS*

Objects	Integrated hydro-morphology	Hydrochemistry		Hydrobiology, integrated	Ecological status/potential
		Oxygen, organic matter	Nutrients		
Channel Charonda-Sypa	AWB	3	4	4	4
Channel Charonda –Latoritsa	AWB	3	3	3	3
Channel Charonda –Tysa	AWB	2	2	2	2
Channel Upper-Sernianskiy	AWB	2	3	3	3
Channel Low-Sernianskiy	AWB	2	2	3	3
Lake (former riverbed) Charonda	3	3	2	2	2

Note. According to WFD: AWB – artificial water body; colors: blue- high, green – good, yellow – moderate, orange – poor, and red – bad status. Ecological potential AWB should be indicated by the equal color/grey stripes (WFD, 2006).

Our results showed that the Charonda-Sypa channel needs urgent measures to improve the ecological potential. All considered characteristics of this water body revealed a critical state. The main reason for the low ecological potential can be seen in the periodical absence of water. The necessary improvement of water regulation should be urgently solved at international level. Although it is open whether this water course (at least the section named Sypa in Ukraine and all sections in Hungary) will be identified as heavily modified water body or as natural water body, the rehabilitation of good ecological status/potential has top-priority.

Channels Charonda-Latoritsa, Upper-Sernianskiy and Low-Sernianskiy also need improvement of ecological potential. In periods preceding excessive growth of aquatic plants, phosphorus, nitrogen and organic matter content indicated class 4 (poor). In summer critical low content of dissolved oxygen due to high mineralization and water temperature was registered (class 5 – bad), leading to the suffocation of fish and invertebrates. However, average annual value of ecological potential was "moderate". Analysis of the biotic community structure and RQBA tables showed that in principle these water courses can be rehabilitated by clearance of their riverbeds from silt deposits and excess growth of the higher aquatic vegetation.

The Charonda-Tysa channel and lake (former riverbed) Charonda revealed a good ecological potential and status. Here Throughout seasons the hydrochemical parameters were similar to those in the above mentioned water bodies, but did not cause a depression of biota. Thus, at present these water bodies do not need expenditures for rehabilitation.

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