Journal of Environmental Protection and Ecology 13, No 2, 476–485 (2012)

Water pollution

MONITORING THE ECOLOGICAL DIVERSITY OF THE AQUATIC DANUBE DELTA SYSTEMS IN TERMS OF SPATIAL-TEMPORAL RELATIONSHIP

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Abstract. The paper proposed the characterisation of a comparative biological analysis of aquatic ecosystems of the Danube delta in 7 sampling sites: Mahmudia, Murighiol, Saint George branch, artificial channel, Uzlina downstream, pontoon Uzlina and Uzlina upstream for the samplings period (February 2009 – June 2010). The preliminary results of analysis for the biotic communities determined from all 7 locations demonstrated the following aspects: in the Mahmudia, Murighiol, Saint George branch, artificial channel, Uzlina downstream, pontoon Uzlina and Uzlina upstream control sections from the phytoplanktonic, zooplanktonic and benthic macroinvertebrates components view point, the Danube water system is an eutrophic system equilibrated for class II according to the Norm concerning the reference objectives for the surface water quality classification (Order MMGA No 161/2006); in the Uzlina control section, the phytoplankton is better represented than in the Murighiol control section for numerical density and remanent biomass. Also, dominant species of phytoplankton and zooplankton – for numerical density and remanent biomass – are oligo-betamesosaprobic species; concerning the benthic macroinvertebrates there is a quite high diversity, represented by gastropods and lamelibranhiates species, association of the oligocheta together with chironomidae organisms. The researches will be continued in order to assess the seasonal variations and to estimate the value of the trophic basis, in the 7 control sections of the Danube delta biosphere, because the main actions that must be achieved in this areas in order to accomplish a sustainable management are represented by: the reduction of the nutrient charge in the Danube, especially the Danube delta inputs, controlling the punctiform and diffuse pollution sources and the restauration of wetlands, this being the only way to prove the capacity to support and productivity of the entire Danubian system.

Keywords: environmental protection, the Danube delta, phytoplankton, zooplankton, benthic macroinvertebrates.

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AIMS AND BACKGROUND

The aquatic ecosystems are dynamic systems that keep their stability in conditions of permanent fluctuations of biotic and nonbiotic parameters. The Danube delta is one of the most important wetland systems in Europe. During the last few decades, the eutrophication process has driven the evolution of the Danube delta aquatic ecosystems to their present conditions. This has resulted in important changes both of water quality and structure of the food web[1,2].

The primary goal of the present research was to study the biotic/population – phytoplankton, zooplankton and/or benthonic components – from the position of the systemic method and conception, in order to characterise the dynamics and role within the integrated aquatic ecosystems[3]. The study of the biotic associations that will be investigated was performed using methods and techniques like: sampling, processing and analysis of samples, field and laboratory experimental methods, quantitative data processing and interpretation.

The main actions that must be achieved in the Danube and Danube delta areas in order to accomplish a sustainable management are represented by:

– the reduction of the nutrient charge in the Danube, especially the Danube delta inputs, controlling the punctiform and diffuse pollution sources;

– the prevention of a wetlands loss through the pressure reduction on them;

– the restoration of wetlands, this being the only way to prove the capacity to support and productivity of the entire Danubian system[4].

For this, the optimisation of the nutrients retention capacity implies a whole approach of the management techniques based on ecological reconstruction tests of the wet lands which suffered an anthropic impact, but also a reduction of the nutrients quantity which go into a different ecosystems through the control of their punctiform and diffuse sources.

In order to decrease the nutrients excess in the punctiform and diffuse sources, a solution could be the fitting out of artificial wetlands, which are capable by the vegetable structure (herbal and/or arboriculture vegetation) to keep big quantities of nutrients.

EXPERIMENTAL

In terms of temporal organisation, this program run with a monthly sampling frequency in accordance with the recommendations of the specific guides and will be directly influenced by biotic compartment – phytoplankton, zooplankton and benthic macroinevertebrates – and of the research purposes. This will be set for captured important stages of life cycles and fluctuation fields of the main factors that influencing the control structure and functions of biotic populations. The biological assessment methods – essential tools used to characterise aquatic biota were represented by: the saprobic system designed by Kolkwitz and Marson which listed the vegetal and animal organisms according to their sensitivity or tolerance of chemical compounds to decomposition of organic substances, naming them indicator pollution organisms and methods that focus on the presence/absence of benthos macroinvertebrates indicators of aquatic communities.

The phytoplankton community represents microscopic floating photosynthetic organisms in aquatic environments; algae come in a variety of shapes and in varied colours due to their different photosynthetic pigments. Algae can be unicellular and microscopic or colonial forming plate-like colonies, thread-like filaments, net-like tubes, or hollow balls. Many planktonic algae species bear horns, ridges or wings to increase their surface area to volume ratio which not only increases their ability to obtain scarce nutrients from the environment, but also protects them from herbivores. Phytoplankton is the foundation of the aquatic food web, the primary producers, feeding everything from microscopic, animal-like zooplankton to multi-ton whales. Because phytoplankton is so crucial to aquatic ecosystems biology and climate, any change in their productivity could have a significant influence on biodiversity, fisheries and the human food supply[5].

The zooplankton organisms are particularly sensitive to pollution, so a lot of these bodies are used as bioindicators. Aquatic benthonic community consists of integrated population biocenoses that live on the river bottom or attached to rocks or other submerged objects.

To achieve the objectives were sampled monthly momentary storage compartments – water and sediment – from the sampling sites in drawing campaigns period February 2009–June 2010, except March 2009, December 2009 and January 2010 due to unfavourable weather conditions and water flow exceeded in order to study the most representatives biotic communities of the aquatic ecosystems (phytoplankton, zooplankton, benthonic macro-invertebrates).

The chosen area for the study was south-east branch of the Danube delta, which includes St. George branch to evaluate the contaminated sites by the distribution of pollutant substances in terms of biotic communities. For this, were established 5 sampling sites that are presented in Table 1 and Fig. 1. Depending on the biological sample type were used special and adequate sampling equipment and the samples were preserved in 4% formaldehyde solution in order to assess the water quality status for February 2009–June 2010 period time. The hydrobiological investigation for all sampling campaigns was performed in accordance with standards methods and methodologies[6–10].

Table 1. The Saint George branch control sections

Crt. No	Placement	Control sections name
1	Mahmudia	S1
2	artificial channel	S2
3	upsteam Uzlina	S3
4	pontoon Uzlina	S4
5	downstream Uzlina	S5
6	Murighiol	S6
7	Sant George branch	S7

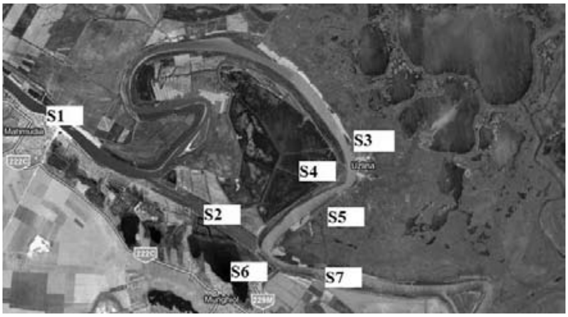

Fig. 1. South-east branch of the Danube delta

RESULTS AND DISCUSSION

The characterisation of biological samples and interpretation of the results has been made in accordance to the Norm concerning the reference objectives for the surface water quality classification (Order MMGA No 161/2006) in order to establish the ecological status of water bodies: very good (I), good (II), moderate (III), low (IV), bad (V) based on biological quality elements, hydro-morphological chemical and physicochemical parameters and to the Directive 2000/60/EC of the European Parliament and of the council establishing a framework for Community action in the field of water policy.

The analysis of the biotic communities in the all sampling site focused on the quantitative (numerical density, biomass, abundance after numerical density and biomass) and qualitative component (dominant species, indicator species). The determination of saprobic indices and saprobic valences for lotic environments according to the method for the saprobic system, successfully used in temperate zones, allows advances in our knowledge about tolerance limits of native species regarding different levels of organic loads[11]. Therefore, it is the basis for a system for water quality assessment. The assessment of saprobic index values for St. George branch control sections revealed uniform distribution of phytoplankton community that induced an ecological state ‘good’ and ‘very good’, with high values of the index recorded in the S6 and S7 control sections.

Concerning phytoplankton community, the all 7 control sections, are represented by microscopic unicellular algae, colonial or filamentous mass flowing water and due to the short life cycles, respond quickly to changes in the aquatic environment. The Bacillariophyta, Euglenophyta, Chlorophyta associations are constant and dominant components in aquatic ecosystems structure for numerical density and biomass – oligo-betamesosaprobic diatoms, betamesosaprobic chlorophyte.

The highest numerical density values of phytoplankton were recorded in S2 (artificial channel) control section in April 2010 (125.000 ex./dm^3) and S4 control section (Uzlina) in October 2009 (116.000 ex./dm^3), decreasing it in winter months (Fig. 2). The lowest value was recorded in S3 (Upstream Uzlina) in March 2010 (7000 ex./dm^3) and S6 (St. George branch) in June 2010. The maximum value of remanent biomass was recorded in June 2009 (0.36 mg/dm^3) in S4 (Uzlina) (Fig. 3). After abundance expressed as a percentage of biomass, in all sampling campaigns the oligo-betamesosaprobic diatom species – *Navicula gracilis*, *Diatoma elongatum*, *Asterionella formosa*[12] or betamesosaprobic chlorophyte – *Pediastrum boryanum*[12] were dominating (Table 3). The most common phytoplankton species are recorded in Table 3.

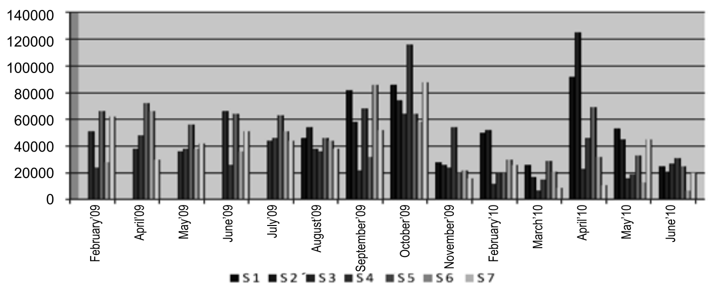

Fig. 2. Average density variation of phytoplankton community in the St. George branch control sections

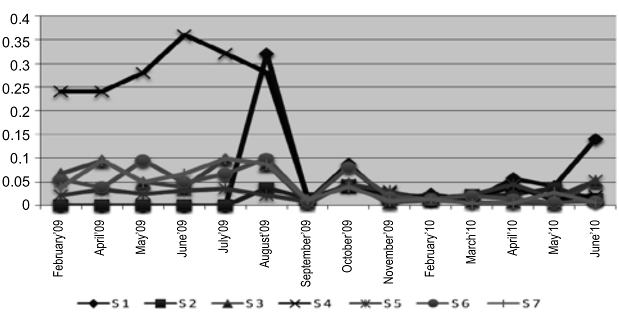

Fig. 3. Biomass variation of phytoplankton community in the St. George branch control sections

Table 2. Biological quality elements for aquatic ecosystems according to Order MMGA No 161/2006

Quality indicator	Quality class (Order MMGA No161/2006)				
	I	II	III	IV	V
Saprobic index	1.8	2.3	2.7	3.2	>3.2

Table 3. Listing of dominant phytoplankton species on the St. George branch sections

Species	S1	S2	S3	S4	S5	S6	S7
Baccilariophyceae							
Diatoma elongatum (o–β)	√	√	√	√	√	–	–
Navicula gracilis (o–β)	–	–	√	√	√	–	–
Synedra acus (β)	–	–	–	√	–	–	–
Asterionella formosa (o–β)	√	–	–	–	–	–	–
Amphora ovalis (α)	–	–	–	–	–	–	√
Navicula rynchocephala (α)	–	–	–	–	–	–	√
Gyrosigma attenuatum (β)	–	–	√	–	–	–	–
Gomphonema stauroneiforme (β)	–	–	√	–	–	–	–
Cymbella lanceolata (β)	–	–	–	–	√	–	–
Diatoma hiemale (o)	√	–	–	–	–	–	–
Cymbella cistula (β)	√	–	–	√	–	–	–
Amphypleura pellucida (β)	–	√	–	–	–	–	–
Chlorophyte							
Pediastrum boryanum (β)	–	–	–	√	–	–	–
Scenedesmus quadricauda (β)	–	–	–	√	–	–	–
Ulothrix tenuissima (o)	√	–	–	–	–	–	–
Euglenophyceae							
Trachelomonas volvocinopsis (β)	–	–	–	–	–	√	–
Phacus longicauda (β–α)	–	–	–	–	–	√	√

Most species in the zooplankton community fall into 3 major groups – Crustacea, Rotifers, and Protozoa. Crustaceans are generally the most abundant, especially those in the order Cladocera (waterfleas), and the class Copepoda (the copepods), particularly the orders Calanoida and Cyclopoida. Most zooplankton are secondary consumers, they are herbivores that graze on phytoplankton, or on unicellular or colonial algae suspended in the water column. The productivity of the zooplankton community is ultimately limited by the productivity of the small algae upon which they feed. There are times when the biomass of the zooplankton at any given time may be similar to, or even exceed that of the phytoplankton. This occurs because the zooplankton communities are relatively long-lived compared with the algal cells upon which they feed, so the turnover of their biomass is much less rapid. In the Danube delta along the St. George branch, the zooplankton community is very well represented by the beta-mesosaprobic rotifers, beta-mesosaprobic species of the cladocers and oligo-betamesosaprobic copepoda. In terms of numerical abundance and biomass throughout the sampling period predominates betamesosaprobic rotifers (*Keratella quadrata frenzeli*)[12] and beta-alfabetamesosaprobic copepods species (*Cyclops strennus metanauplius*)[12]. The lowest values of zooplankton organisms and even their absence were recorded in June 2010 and are explained because the river high flows surpassing the rates of the Danube delta reaching 13 100 m^3/s. The highest numerical density values (880 ex. /dm^3) was recorded in S6 (Murighiol) in September 2009 and 720 ex./dm^3 in October 2009 (Fig. 4); the maximum value of remanent biomass was recorded in September 2009 (0.28 mg/dm^3) in S2 (artificial channel) (Fig. 5).

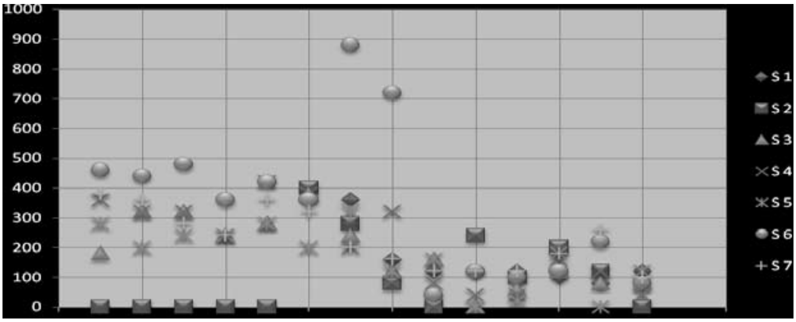

Fig. 4. Average density variation of zooplankton community in the St. George branch control sections

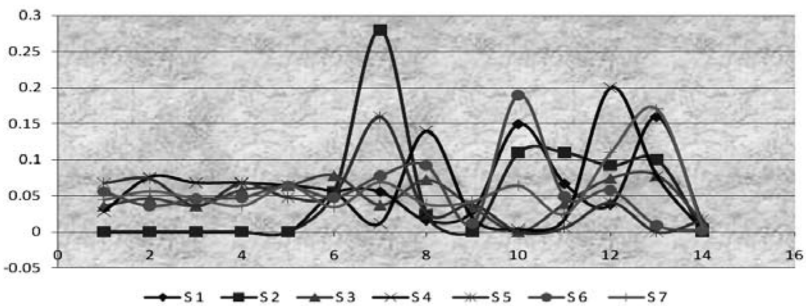

Fig. 5. Biomass variation of zooplankton community in the St. George branch control sections

Referring to benthonic macro-invertebrates – those organisms that live on/or in the substrate of aquatic ecosystems, living freely or inside of own houses are affected by the human interventions on sediment include retaining and collecting the eroded soil and rock materials on the slopes of basins; damming the rivers for navigation and energy production purposes; dredging the bed material from the river channel for industrial use at a rate much higher than the bedload transporting potential of the river[13]. Because of the summarised effects of these anthropogenic factors, the suspended sediment and bed load transport show a decreasing tendency at almost every station investigated.

In fact, gastropods and lamellibranchiate species, and the oligocheta association together with chironomidae organisms that are important links in aquatic ecosystems were dominant. The highest value of numerical density was recorded in February 2009 in S4 (Uzlina) – 35 000 ex./dm^3, lamellibranchiate and gastropods species were dominant. Spatial-temporal distribution of the numerical density and biomass for macro-invertebrates in each of the sampling locations for entire period is represented in Figs 6 and 7. In the 7 established control sections are found a variety of macro-invertebrates comunity represented by gastropods, lamellibranchiata, Oligochaeta, Chironomida, other Diptera species, ostracoda and, sporadically, Isopoda or Amphipoda. The lowest values of numerical density and remanent biomass were registered in S2 control section, where Oligochaeta species were dominated. In March 2010 sampling campaign were identified 2 species of the super-class bony fish Osteichthyes, Actinopterygii class, Neopterygii sub-class, infra-class Teleostei, Ostariophysi supra-order, Cypriniformes order, Cobitidae family – species *Cobitis taenia* in S4 (Uzlina). Along the sampling campaigns, a heterogeneity in benthic hydrobionts was founded in S3 (upstream Uzlina), S4 (Uzlina) and S5 (downstream Uzlina) checkpoints with dominant lamellibranchiate and gastropods species.

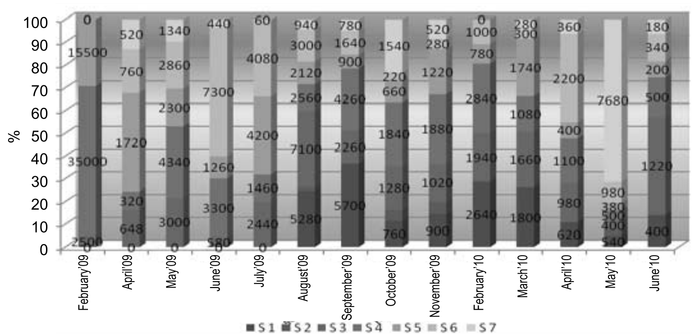

Fig. 6. Average density variation of benthonic macro-invertebrates in St. George branch control sections

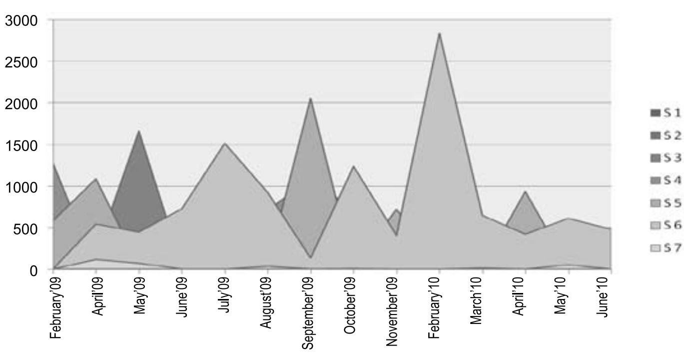

Fig. 7. Biomass variation of benthonic macro-invertebrates in St. George branch control sections

Following analysis of phytoplankton and zooplankton in samples of water and sediment represented by macrozoobenthic, the water quality studied fits into class II corresponding with good ecological status due saprobic index values and the predominance of oligo-betamezosaprobic and betamezosaprobic species.

CONCLUSIONS

The results of these investigations enable to draw certain conclusions at the moment, important for the survey of the present and future quality of the water, as well as for the direction of the necessary future investigations[14,15]. The phytoplanktonic and zooplanktonic biocenosis represents the trophic basis necessary for ichthiofauna development in the aquatic ecosystems in the control sections and dominant species from phytoplankton and zooplankton – for numerical density and remanent biomass – are oligo-betamesosaprobic species. In the sediment, lamellibranchiate species shows a very important ecological role in water purification due to their mode of nutrition. The Danube water is an eutrophic system equilibrated for class II according to the Norm concerning the reference objectives for the surface water quality classification (Order No 161/2006). The researches will be continued in order to assess the seasonal variations, the final results will estimate the value of the trophic basis, in the 7 sampling sites in the framework of the Danube delta biosphere[16–18], because the main actions that must be achieved in this areas in order to accomplish a sustainable management are represented by: the reduction of the nutrient charge in the Danube, especially the Danube delta inputs, controlling the punctiform and diffuse pollution sources; the prevention of a wetlands loss through the pressure reduction on them; the restoration of wetlands, this being the only way to prove the capacity to support and productivity of the entire Danubian system.

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Received 14 January 2011
Revised 20 June 2011