pp. 39-42 doi:10.7427/DDI.21.04

4. Water quality in Danube Delta Lakes: An assessment using benthic macroinvertebrates community

IBRAM Orhan

Danube Delta National Institute, no. 165, Babadag Street, 820112, Tulcea, Romania, e-mail:orhan.ibram@ddni.ro

Abstract: An assessment of the ecological status of selected lakes in the Danube Delta Biosphere Reserve was done based on temporal and spatial variation of macroinvertebrate communities during 2012 and 2013. Macroinvertebrate communities and measures of these communities were evaluated and a baseline characterization of assemblages was determined for the analyzed sites. Each year, three sampling campaigns, one for each ice-free season were organized for data collection. Macroinvertebrate samples have been collected in every lake from three different stations with the use of an Ekmann dredge. The highest taxa richness are recorded in Fortuna and Isac lakes in 2013. Total abundance followed a pattern similar to taxa number with Fortuna and Isac lakes having the highest yearly values (maximum number of individuals – 225 - per sample has been recorded in September 2013, in Isac Lake).Using saprobic index as an indicator of ecological status Isac lake was classifies as moderate and other three lakes, Merhei, Furtuna and Rosu as good ecological status. Lack of correlation between diversity indices and the saprobic values suggests that other assessment methods could be more effective and provide better information than saprobic index does at least for Danube Delta.

Key words: Water Framework Directive, ecological status, benthic invertebrates, Danube Delta

INTRODUCTION

Being among the most productive complex of ecosystems, wetlands plays an important role for people because of the ”services” they provide. Whether it be food provision, flood control, climate change mitigation or biodiversity, all represented arguments for the designation of Danube Delta as a Biosphere Reserve, in 1990. It was also listed as a Ramsar Wetland of International Importance. The second largest delta in Europe, Danube Delta Biosphere Reserve covers around 580,000 hectares and is located in the eastern part of Romania acting as a buffer between Danube river and the Black Sea.

Shallow lakes are important for biodiversity [13], [19], [5]. However, human impact such as eutrophication and pollution has increased causing disturbances of the food web and species loss [16].

In Europe, a shift from a chemically oriented monitoring of water quality to a more holistic approach has been prompted by the Water Framework Directive (WFD, Directive 2000/60/EC) requirements [23]. Annex V of the WFD lists three main parameters of the macroinvertebrate community required for ecological assessment: diversity, taxonomic composition and abundance. Restoration from moderate to at least good status is required when these parameters differ from type specific reference conditions to an extent coincident with the absence of major taxonomic groups. These parameters are not exclusive and others may be included to achieve the overall aim of an ecological status designation of the WFD as an “expression of the quality of the structure and functioning of aquatic ecosystems” [23].

Understanding the mechanisms guiding the species distribution, their presence or absence in different habitats and environments represents one important step in assessing the ecological status. In the last years a lot of effort has been committed to the development of tools to help in ecological status assessment. Aquatic macroinvertebrates like many other taxonomic groups such as phytoplankton, fish or birds are one of the most frequently used. The majority of studies promoting macroinvertebrates as a tool for monitoring water-quality have concentrated on rivers [12]. For lakes only fewer studies considered the use of macroinverbrates [14], [18], [8].

WFD has stimulated an increase in methods and metrics for ecological status assessment using aquatic invertebrates [1]. In the Romanian legislation only threshold values for saprobic index are defined [22].

The goal of this study is to present (1) an overall picture of the macroinvertebrate communities from four of the Danube Delta lakes, (2) the water quality of the investigated lakes based on benthic invertebrates.

MATERIALS AND METHODS

All lakes in Danube Delta are shallow and polymictic with an average depth less than 3 meters. To capture habitat heterogeneity of the area four sites (lakes) located in different regions of the delta were chosen as sampling sites in this study.
Quantitative benthic macroinvertebrate samples were collected with an Ekmann grab with a surface size of 0.025 m^2. Three replicate samplings were taken at each of the 4 lakes in March, May and September 2012 and 2013. The samples were sieved through 0.500 mm mesh and fixed in 70% ethanol on site. In the laboratory, all samples were identified to the lowest possible taxonomic level, which were usually genera or species for chironomidae. All oligochaets were pooled under one single taxon represented by class. Identification of the sampled organisms was performed using mainly the keys of Botnariuc, Wiederholm for Chironomidae [2], [21], Grossu for Bivalvia and Gastropoda [10], [11], Cărăușu for Amphipoda [3], Elliot for Hirudinea [6] and Nilsson for Ephemeroptera [15].

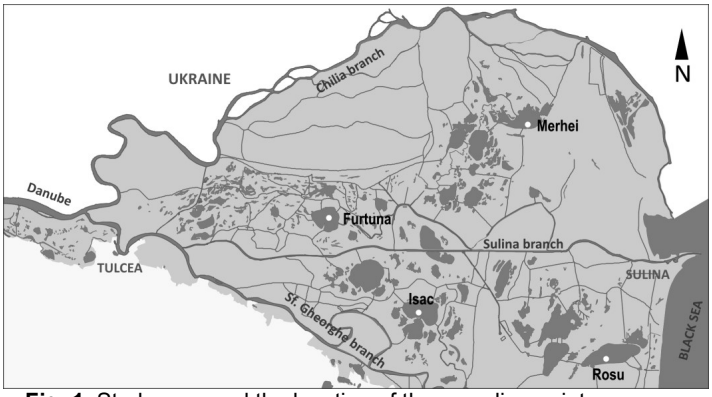

Fig. 1 Study area and the location of the sampling points

We analyzed all three parameters listed in annex V of the WFD. Using Asterics software, version 4.0.4, three diversity indices have been calculated: Simpsons, Shannon-Wiener and Margalef. In addition to diversity, taxonomic composition and abundance parameters, we examined another biological indicator of water quality namely, the saprobic index. The classification in different ecological status classes was done using the threshold values from Romanian legislation [22]. This index is based on the observation that there are different degrees of water pollution with organic matter and therefore the macroinvertebrates that inhabit these waters are different. Their presence is conditioned by the quality and the quantity of food, by some physical and chemical properties of water, especially the amount of dissolved oxygen and the quantity produced by the decomposition of organic matter. The analysis of similarity, using Bray-Curtis index between different lakes or sampling dates was tested with Primer version 6 [4].

RESULTS AND DISCUSSION

Dredge sampling yielded the identification of 83 macroinvertebrate taxons representing different systematic groups: Oligochaeta, Hirudinea, Crustacea, Bivalvia, Gastropoda, Ephemeroptera, Odonata and Diptera. Chironomidae was the most abundant group.
The highest taxa richness are recorded in Fortuna and Isac lakes in 2013, from the samples collected in September (figure 2). In general, both of the mentioned lakes have higher taxon richeness in the investigated period being also most constant regarding the number of taxons. Roșu and Merhei lakes are characterized by a greater difference between different years. There are no important differences between the years. The highest dissimilarity between lakes across both years is given by Isac-Roșu pair (average dissimilarity was 28. 45%). The first one has an average number of taxons of 14, while the second, Roșu Lake, has a number of 7 taxons, on average. The number of species is sensitive to either number of individuals or samples observed or collected [9]. This is the reason why in this research the number of taxon represents a measure of taxon density or the number of taxons collected only in the specific area where the samples were collected.

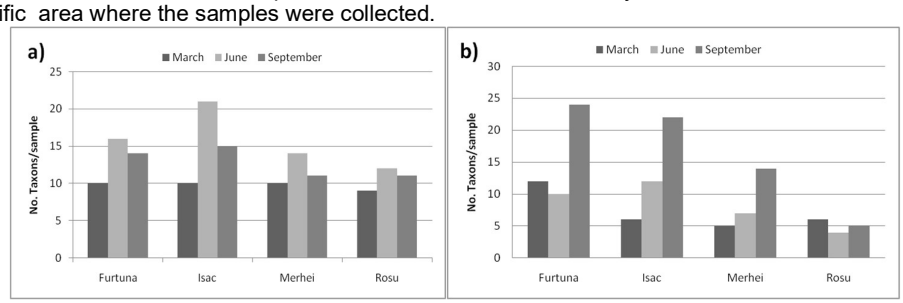

Fig. 2 Taxon number in 2012 (a) and 2013 (b)

Total abundance followed a pattern similar to taxa number with Fortuna and Isac lakes having the highest yearly values (maximum number of individuals – 225 - per sample has been recorded in September 2013, in Isac Lake). In all lakes a constant high relative abundance of chironomids has been recorded.

Another assessed parameter was diversity indexes. There are no (yet) threshold limits between quality classes using this indicator for Romanian water bodies. The Shannon-Wiener index varies from values of 0 for communities with one species, to various other values for other species mixes. The values for the four lakes in 2013 vary between 1.16 and 2.65.

In 2012 both minimum (1.82) and maximum (2.83) values are higher than in 2013. For Simpson and Margalef indexes value ranges lies between 0.82-0.95 in 2012 and 0.69-0.92 in 2013 respectively between 2.14-5.13 in 2012 and 1.25-4.78 in 2013. Regarding macroinvertebrate abundances, both between the two years (2012 and 2013) and different seasons there are significant differences. Summer and spring samples proved to be less similar with respect to macroinvertebrate community abundances (average Bray-Curtis dissimilarity = 82. 38%). Most identified species are tolerant to organic enrichment.

In terms of saprobic index all lakes are classified as good ecological status with the exception of Isac Lake. Even though the summer and autumn values of the saprobic index are characteristic for good or moderate ecological status, because in the spring macroinverbrate community is represented by high abundances of Chironomidae, with numerical dominance of *Chironomus plumosus* and *Chironomus riparius,* species being highly tolerant to pollution thus with high saprobic values. Overall, average ecological status of Isac Lake is poor in 2013 and moderate in 2012. No correlation was found between any of the calculated diversity indexes and the saprobic index (Pearson's correlation coefficient with Simpson index was r=0.194 with Shannon index r=-0.07, and with taxon number r=0.03)

Main factors inducing and sustaining the evolution of trophic state in Danube Delta lakes were the progressive rise in nutrient concentration and floodplain reduction. The later had filtering function both inside delta and along Danube River. As a result of eutrophication aquatic food webs were heavily affected. Starting with primary producers a simplification by reduction or even complete disappearing of different lakes biotic compartments like aquatic macrophytes and the associated macroinverbrates has occurred in Danube Delta.

Similar to other authors findings [7], *Chironomus sp.* are the dominating species which can cope with severe oxygen depletion and can be, in this condition, the only important energy carries between particulated organic matter and fish species. The decline in deposit feeder benthic fauna due to eutrophication was one of the reasons of fish stocks decline in Danube Delta [17].In the bottom fauna of all four lakes a predatory chironomid species, *Procladius choreus* has been well represented in the entire period of the study. The dominance of the same species was observed in other researches of benthic invertebrates from Danube Delta [17].

Although the water quality improved and the plankton communities seem to recover [20], the structural and functional parameters of the benthic community are still below but approaching the values recorded before 1980 then the eutrophication started to intensify.

CONCLUSION

The efficacy of the saprobic system represented a subject matter for controversy in the last decades. This study shows that in Danube Delta, because of homogeneity of trophic conditions, and the presence of tolerant species in high abundances the saprobic index could indicate a poor ecological status even if the number of species is higher than in samples with a better ecological status indicated by saprobic index. For macroinvertebrates other ecological status assessment methods could be more effective and provide better information than saprobic index does.

The applicability and geographic scaling of better performing methods capable of addressing more than one pressure - eutrohication and morphological alterations - should be tested and adapted for Danube Delta specific environmental conditions.

ACKNOWLEDGEMENTS

This research was supported by by EU Black Sea Crossborder project, "Innovative Instruments for Environmental Analysis in North Western Black Sea Basin." We thank to Cosmin Spiridon for his help in sampling and benthic invertebrates sorting.

REFERENCES

1. BRUCET (S.), POIKANE (S.), LYCHE‐SOLHEIM (A.), BIRK (S.), 2013 - Biological assessment of European lakes: ecological rationale and human impacts. IN: *Freshwater Biology***,** 58 (6), 1106-1115.
2. BOTNARIUC, (N.), CURE, (V.), 1999 - Determinator al larvelor de Chironomidae (Diptera) din fauna României. Editura Academiei Române.
3. CĂRĂUŞU (S.), DOBREANU (E.), MANOLACHE (C.), 1955 - Crustacea: Amphipoda forme salmastre şi de apă dulce. Editura Academiei Republicii Populare Romane, Bucuresti, 1-407.
4. CLARKE (K.R.), GORLEY (R.N.), 2006 - PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth, 192 pp.
5. DECLERCK (S.), VANDEKERKHOVE (J.), JOHANSSON (L.), MUYLAERT (K.), CONDE-PORCUNA (J.M.), VAN DER GUCHT (K.), PÉREZ-MARTINEZ (C.), LAURIDSEN (T.), SCHWENK (K.), ZWART (G.), ROMMENS (W.), LÓPEZ-RAMOS (J.), JEPPESEN (E.), VYVERMAN (W.), BRENDONCK (L.), DE MEESTER (L.), 2005 - Multi-group biodiversity in shallow lakes along gradients of phosphorus and water plant cover. IN:*Ecology*, 86, 1905–1915.
6. ELLIOT (T. J. M.), MANN (K. H.), 1979 - A key to the British freshwater leeches: with notes on their life cycles and ecology (No. 40). Hyperion Books.
7. ERSAN (E.), ALTINDAG (A.), ALTINDA (S.), ALAS (A.), 2009 - Zoobenthic fauna and seasonal changes of Mamasin dam lake (Central part of Turkey). IN:*African Journal of Biotechnology*, 8 (18), 4702-4707.
8. GABRIELS (W.), LOCK (K.), DE PAUW (N.), GOETHALS (P. L.), 2010 - Multimetric Macroinvertebrate Index Flanders (MMIF) for biological assessment of rivers and lakes in Flanders (Belgium). IN:*Limnologica-Ecology and Management of Inland Waters*, 40(3), 199-207.
9. GOTELLI (N. J.), COLWELL (R. K.), 2001 - Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. IN:*Ecology Letters***,** 4(4), 379-391.
10. GROSSU, (A. V.), 1986 - Gastropoda Romaniae (Vol. 1). Editura Litera, Bucuresti.
11. GROSSU, (A. V.), 1962) - Bivalvia. Fauna RSR, 3(3), Editura Academiei Romane, Bucuresti, 1-426.
12. HERING (D.), MOOG (O.), SANDIN (L.), VERDONSCHOT (P. M.), 2004 - Overview and Application of the AQEM Assessment System. IN:*Integrated Assessment of Running Waters in Europe*. Springer, Netherlands. 1-20.
13. JEPPESEN, (E.), SONDERGAARD, (M.), CHRISTOFFERSON (K.), 1998 - The Structuring Role of Submerged Macrophytes in Lakes. Springer Verlag, New York.
14. MOSS (B.), STEPHEN (D.), ALVAREZ (C.), BÉCARES (E.), BUND(W. V. D.), COLLINGS (S.), DONK (E. V.), EYTO (E. D.), FELDMANN (T.), FERNÁNDEZ‐ALÁEZ (C.), 2003 - The determination of ecological status in shallow lakes - a tested system (ECOFRAME) for implementation of the European Water Framework Directive. IN:*Aquatic Conservation: Marine and Freshwater Ecosystems* 13(6): 507-549.
15. NILSSON (A. N.), 1996 - Aquatic insects of North Europe: a taxonomic handbook. Volume 1: Ephemeroptera, Plecoptera, Heteroptera, Neuroptera, Megaloptera, Coleoptera, Trichoptera, Lepidoptera. Apollo books.
16. SCHEFFER (M.), 1998 - Ecology of Shallow Lakes. Chapman and Hall, London.
17. VĂDINEANU (A.), CRISTOFOR (S.), IGNAT (G.), CIUBUC (C.), RÎŞOVEANU (G.), BODESCU (F.) (N.) BOTNARIUC, 2001 - Structural and functional changes within the benthic communities of Danube Delta lakes. IN:*Internationale Vereinigung fur Theoretische und Angewandte Limnologie Verhandlungen* 27(5): 2571-2576.
18. WHITE (J.), IRVINE (K.), 2003 - The use of littoral mesohabitats and their macroinvertebrate assemblages in the ecological assessment of lakes. IN:*Aquatic Conservation: Marine and Freshwater Ecosystems*, 13(4), 331-351.
19. WILLIAMS (P.), WHITFIELD (M.), BIGGS (J.), BRAY (S.), FOX (G.), NICOLET (P.), SEAR (D.), 2004 - Comparative biodiversity of rivers, streams, ditches and ponds in an agricultural landscape in Southern England. IN:*Biological Conservation*, 115, 329–341.
20. ZINEVICI (V.), IONICĂ(D.), PARVALĂ (L.), SANDU (C.), MUŞA (R.), DOBRE (D.), 2006 - Diversitatea unor comunitati de organisme acvatice in sisteme ecologice din zonele Erenciuc şi Gorgostel (Delta Dunarii). Ars Docendi, Bucureşti, pp.302.
21. WIEDERHOLM (T.), 1983 - Chironomidae of the Holarctic region: keys and diagnoses. P. 1, Larvae. Entomologica Scandinavica.
22. *** Ordinul 161/2006 - Normativ privind clasificarea calităţii apelor de suprafaţă în vederea stabilirii stării ecologice a corpurilor de apă, Ministerul Mediului si Gospodaririi Apelor, Monitorul Oficial, Partea I nr. 511 din 13/06/2006
23. ***Directive 2000/60/EC of the European Parliament and of the Council; establishing a framework for Community action in the field of water policy, European Communities Official Journal L 327: 22.12 Brussels