Towards an Ecosystem-Based Management in the Lower Danube Region (Romania)

Către o gestionare bazată pe ecosisteme în regiunea Dunării inferioare (România)

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Abstract

The paper aims to integrate the assessment of aquatic ecosystems degradation through the eutrophication process with impact on development of the social life and on the present status of administrative measures, in order to insure a future coherent application of the Ecosystem Based Management (EBM) approaches.

Keywords: *Danube Delta, Ecosystem Based Management*

Introduction

Since 1975, the environmental stresses on delta's ecosystems and Romanian North-Western Black Sea coast have increased markedly. The effects of contamination from agricultural runoff, municipal waste disposal, all dams, dikes, channelization and other hydraulic alterations along the entire river stretch, which contributed to the decreasing of nutrient cycling and purification capabilities of the wetlands, fishing or reed harvesting, have led to the ecological changes in the lower part of the Danube River, Danube Delta and in the coastal Black Sea shelf.

The Danube Delta is faced by serious cyanobacteria bloom risks due to eutrophication and climate change being vulnerable to ecological decline, which also involves challenging issues of biodiversity conservation, restructuration of the wetlands and improving the human well being. In searching of practical application of the EBM approaches for the achievement of biodiversity targets in the Danube Delta Biosphere Reserve we will explore synergies between research priorities for Danube-Black Sea System and actual management mitigation measures as potential ways of synchronising the vision of stakeholders and researchers in a coherent approach to the problems faced.

Materials and Methods

The authors explore the trade-offs between decisions, drivers, pressures, state of environment and synergies of biodiversity and ecosystem services (Ecosystem Based Management principle) related to eutrophication and hydro-morphological alterations of the channels inside of the Danube Delta Biosphere Reserve. The socio-ecological system was analyzed with respect on its trend.

Results and Discussion

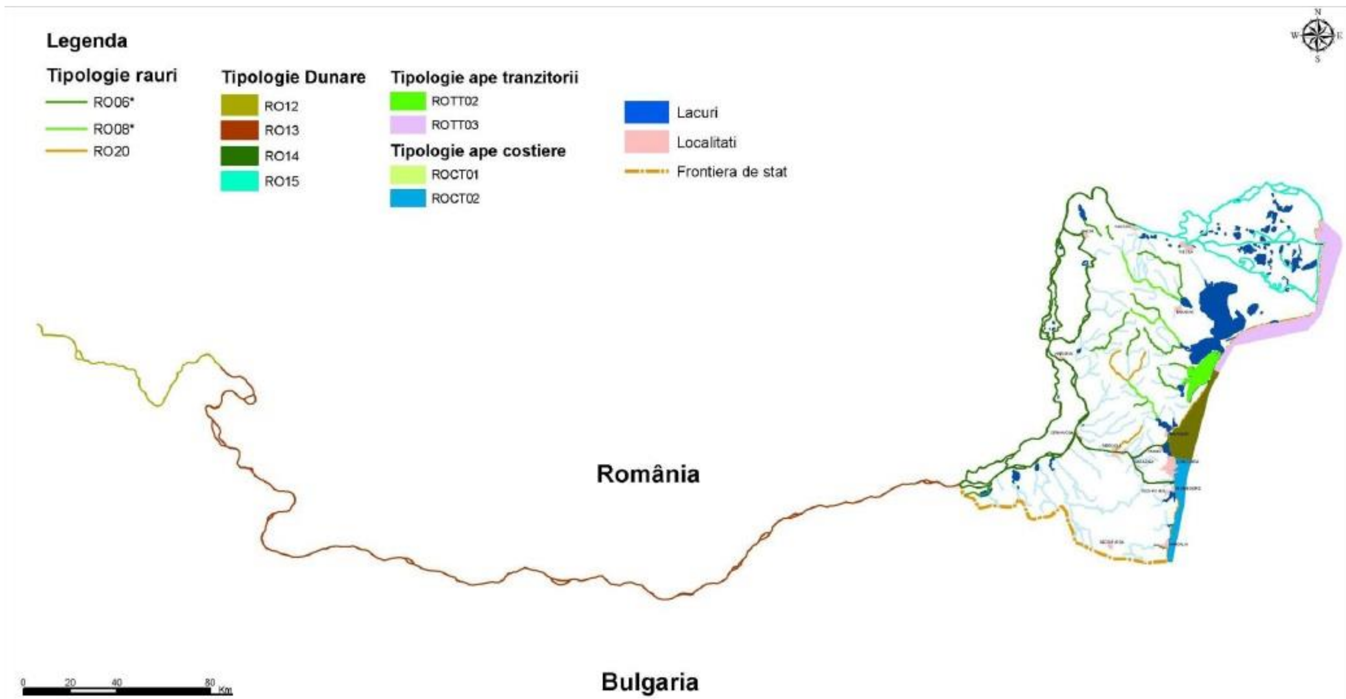
In accordance with Annex XI of the Water Framework Directive, the Romanian sector of the Danube River (Figure 1) belongs to the Pontic eco-region (12), which is characterized by a slightly curved relief at the boundary with eco-region 10, altitudes below 500 m, predominantly silky geology, chernozem soils and gray soils, deciduous forests and agricultural areas. Inside this eco-region a particularity is the Danube Delta, which is a unique ecosystem, designated as ROSPA0031 – Danube Delta and its transitory area: Complexul Razim-Sinoie, ROSCI0065 – Danube Delta, accounting 30 types of ecosystems, of which 50% are represented by aquatic ecosystems (***, 2009).

Danube Delta is located in the south-eastern part of Europe, having 84% of the total area in Romania and it is one of the largest protected areas in Europe. The Romanian Danube Delta Biosphere Reserve (DDBR) (Figure 2) lies at the intersection of 45° N (parallel of latitude) with 29° E (longitude). The total area of DDBR is of about 5,800 km^2 more than half of which (3,510 km^2) belong to what is commonly called the “Danube Delta”, while the remaining area is shared between the upstream Danube floodplain (Isaccea-Tulcea sector 102 km^2), the Razim-Sinoie lagoon complex (1,145 km^2), the neighbouring strip from the Black Sea (1,030 km^2) up to the 20 m isobaths, and the Danube river between Cotul Pisicii and Isaccea (13 km^2) (GÂȘTESCU, 2009). The main morphohydrographic categories are: predeltaic territories, river and sea sand banks, hydrographical network (main branches, streams and channels), lakes, swamp areas (***, 2006).

Since 1993, by several Romanian Government decisions, the legislation regulating the DDBR statute, as a protected area, has suffered many modifications in order to improve the management action related to conservation, protection, regulation and control of the Danube Delta Biosphere Reserve Administration (BELACURENCU, 2007).

In the context of the preservation and maintenance of its natural state, through governmental act (H.G. nr. 248/ 1994), the Danube Delta Biosphere Reserve has been delimited as:

- ✓ 18 strictly protected areas, with an area of 50.600 ha (8.7% of its total area).
- ✓ 13 buffer zones, with an area of 223,300 ha (38.5% of its total area)
- ✓ economic zones, with an area of 306,100 ha (52.8% of its total area)



Note: *tipologie = typology; ape trazitorii = transitional waters; ape costiere = coastal waters; lacuri = lakes; localitati = settlements; frontiera de stat = state border*

Figure 1. Typology of watercourses, transitional and coastal waters
(according to: National Agency Romanian Waters Directorate Dobrogea Seaside (ANAR – ABA Dobrogea Litoral)
http://www.rowater.ro/sites/en/default.aspx

Fig. 1. Tipologia cursurilor de apă, tranzitionale și costiere
(conform Agenției Naționale Apele Române – Administrația Bazinală de Apă Dobrogea Litoral)

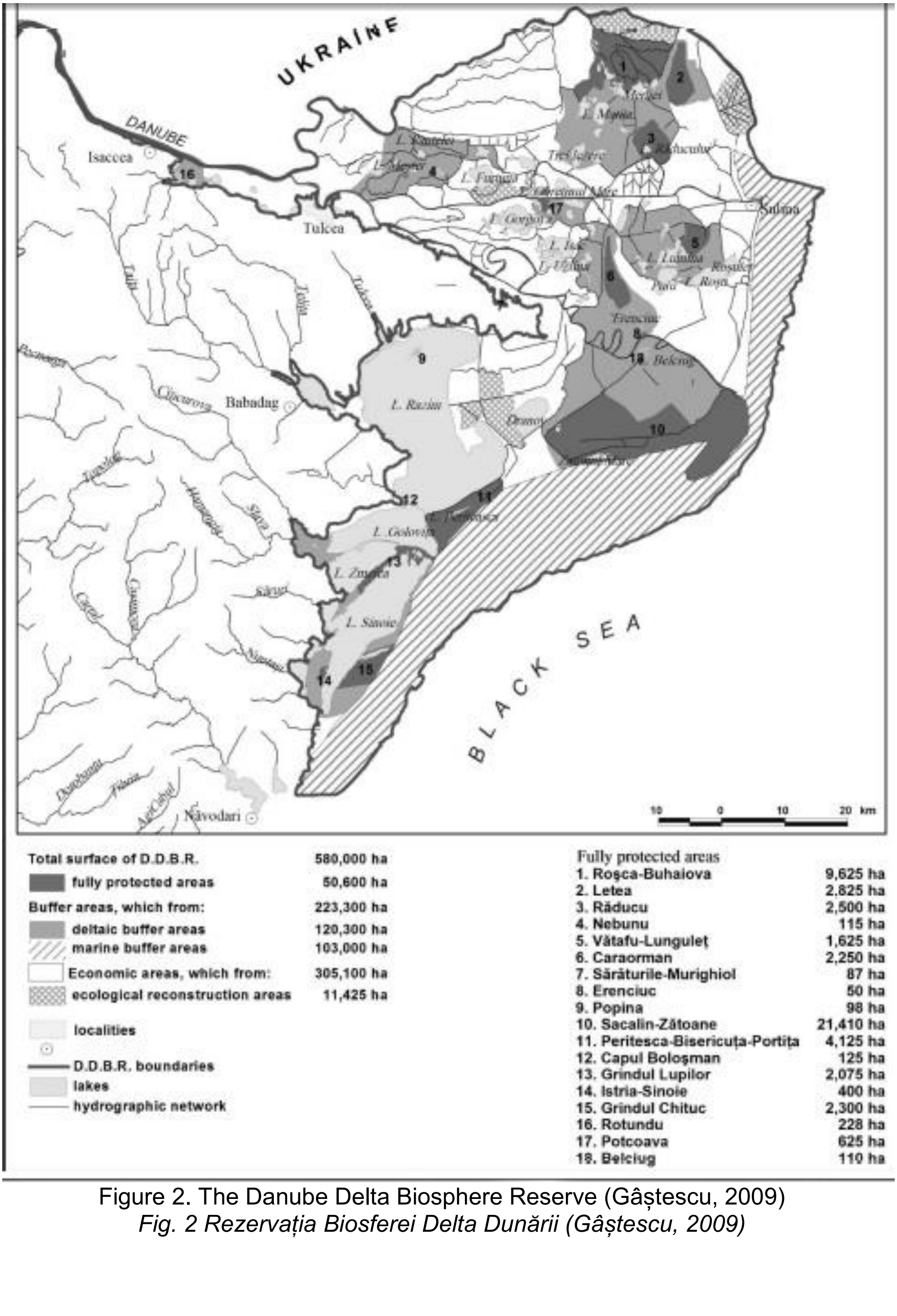


Figure 2. The Danube Delta Biosphere Reserve (Gâștescu, 2009)

Fig. 2 Rezervația Biosferei Delta Dunării (Gâștescu, 2009)

In order to implement the Water Framework Directive in the Danube Delta, through the monitoring programs carried out since 2000, the inner delta was classified into three categories of lakes: **type 1** lakes, which are 2 to 4 m deep and larger than 200 ha, having sand-silt substrate and an intermediate inflow of turbid river water with high abundance of cyanobacteria and cladocera, a low abundance of aquatic vegetation, and a predominantly eurytopic fish community; **type 2** lakes, with a high river water input, intermediate size and water depth with a strong seasonal dynamics in water level, having clear water, where zooplankton is scarce, but filamentous algae are abundant, as their aquatic vegetation, and the fish communities are predominantly eurytopic; **type 3** lakes, which are located in the parts where reed colonization and peat accumulation are dominant, have relatively small and shallow water depth, with clear water, low abundance of zooplankton, being copious in aquatic vegetation and eurytopic fish are scarce (OOSTERBERG *et alii*, 2000; COOPS *et alii*, 2008).

According to Natura 2000 habitats classification in the Danube Delta can be found the following 29 types of natural or partly man-induced habitats (Figure 3) (DOROFTEI, 2013):

- ✓ 1110 Sand banks which are slightly covered by sea water all the time (location: sea side area);
- ✓ 1130 Estuaries (location: Musura and Sacalin’s Bay);
- ✓ 1140 Mudflats and sand flats not covered by seawater at low tide (location: sea side area);
- ✓ 1150* Coastal lagoons (location: On the Romanian territory of The Black Sea, this habitat is represented by the lagoon complex of Razim – Sinoie and Zăton Lake);
- ✓ 1160 Large shallow inlets and bays (location: coastal areas of DDBR)
- ✓ 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/ or *Isoëto-Nanojuncetea* (location: Portița, Perișor, Sulina, Leahova, Grindul Chituc and Grindul Lupilor);
- ✓ 3140 Hard oligomesotrophic waters with benthic vegetation of *Chara* subsp. (location: most of the type 3 lakes (small size – clear waters) from the CAMP area – Nebunu, Răducu, Gherasim, La Amiază, Chiril, Potcoava Lake, Lunguleț, Porcului, Pojarnia, Bondarului and Rotund from Gorgova-Uzlina lake establishment);
- ✓ 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* – type vegetation (location: most of the type 1 lakes (large size) and 2 (medium size) from the Danube Delta);
- ✓ 3160 Natural dystrophic lakes and ponds (location: fish ponds, channels and lakes (type 2) from the Danube Delta);

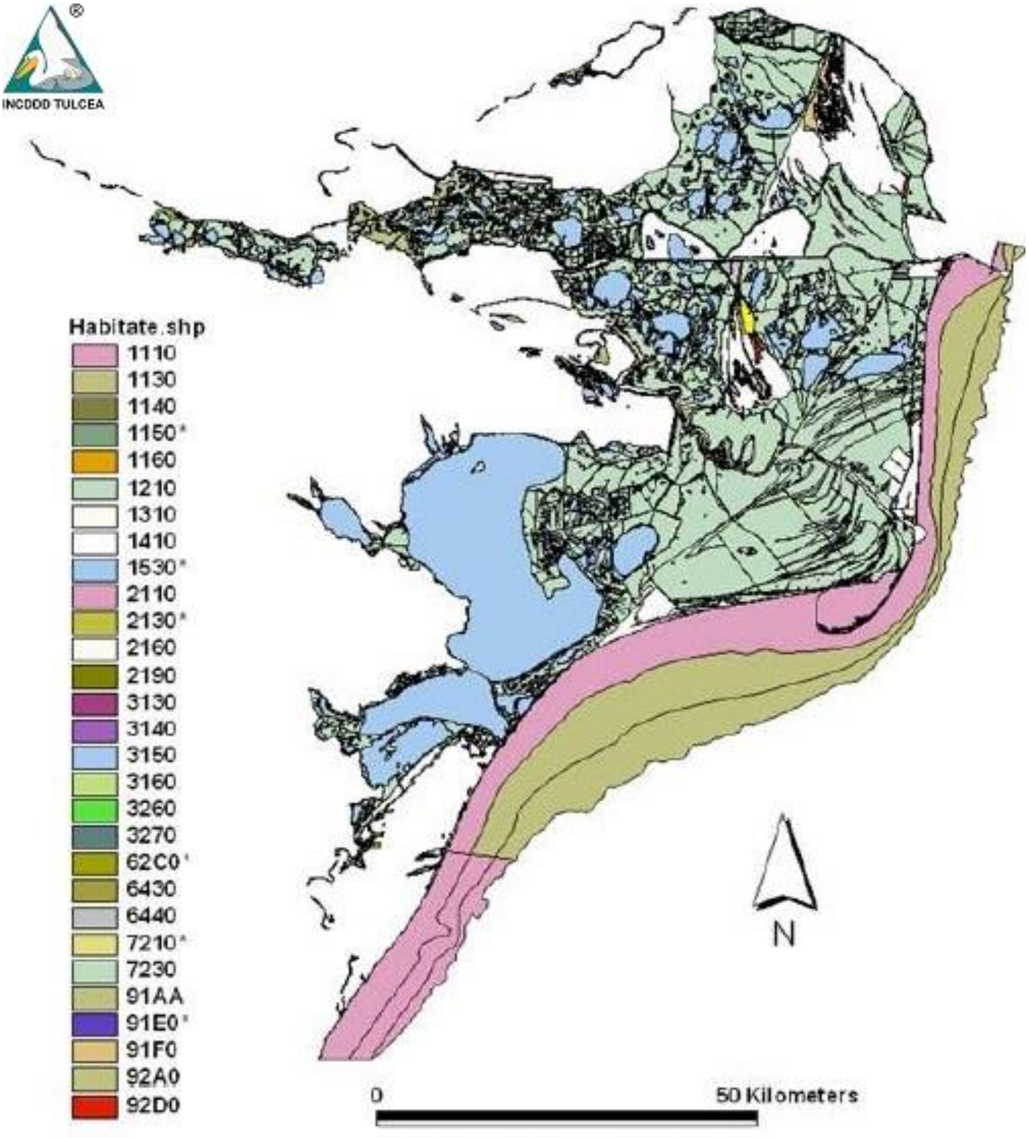


Figure 3. Natura 2000 habitats in the Danube Delta Biosphere Reserve (Doroftei, 2013)

Fig. 3. Habitate Natura 2000 în Rezervația Biosferei Delta Dunării (Doroftei, 2013)

- ✓ 3260 Water courses of plain to mountain levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (location: Erenciuc, Dunavăț-Dranov and Șontea-Fortuna lake establishments);
- ✓ 3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation (location: Șontea-Fortuna, Dunavăț-Dranov, Gorgova-Uzlina and Roșu-Puiu lake establishments).

In terms of legal status, more than 80% of the Reserve's lands belong to the public domain of national interest being administered by the Authority of the Danube Delta Biosphere Reserve, the rest of the area being the public domain of local interest (about 19%) and private. Most of the land is water and wetland (71.51%); arable land with permanent crops (13.71 %); forest and shrubs lands (5.28%); permanent grassland (6.77%); unused or other uses lands (2.73%) (***, 2009).

The Danube Delta acts as a complex social-ecological system where the main driving forces of wetland changes include human activities. A total of 13 ecosystem services and 10 sub-services including provisioning services, cultural services, regulating services and habitat/supporting services were identified, described and assessed in the Danube Delta Biosphere Reserve (GÓMEZ-BAGGETHUN *et alii*, in press).

According to HABERL *et alii* (2009), the reference configuration (before1950s) of the Inland Danube Delta-Socio Ecological System was able to deliver significant regulatory services. After Second World War until the early 1990s giving up to the rural and agriculture-based economy determined a strong pressures on ecosystems which led to a massive changes in the structure and function of the natural capital (80% of the delta were converted into agricultural land; fish catches fell below 1 kt/ yr; the nutrient retention capacity fell below 5 kt N/ yr and 0.25 ktP/ yr.; to 1.8 km^3 of water flood retention capacity; occurred habitat fragmentation and eutrophication; food availability been diminished). Nowadays, specific features of this system includes: sparse and isolated population, economical specialization and vulnerability, poor access to services which implies support provided for investments and compensatory payments for income losses for agricultural environmental practices and areas with specific natural constraints, has significant negative impact on the buffering capacity and on the amount and quality of the provided resources and services (***, 2014; VĂIDIANU *et alii*, 2015).

The long-term societal and environmental challenges and the conflict between environmental targets and economic development of the Danube Delta Biosphere Reserve localities, are issues associated to an inefficient environmental awareness system, lack o solutions for better job and sustainable use of resources (PETRIŞOR *et alii*, 2016). Due to its geographic position and the large variety of economic and environment activities which nowadays take place in the delta and the adjacent coastal areas of the Romanian Black Sea the synergies between the EUSDR and the Integrated Maritime Policy for the Black Sea coast (Blue Growth Strategy) should be the most relevant at the local level (***, 2014a).

Human activities affected in different ways the natural patrimony of the DDBR and areas located in the Danube river valley, upstream of the DDBR.

The main civil works performed in the DDBR were building of dams (activity that drastically reduced or practically eliminated several types of natural habitats – i.g. the ones suitable for amphibians and other species adapted to wetlands –, modified the reproductive patterns of various fish species – mostly the ones belonging to *Cyprinidae* family – and interrupted the lateral connectivity). Meanwhile, the periodical and frequent dredging (de-clogging) of channels affected several species depending on the undisturbed waterways (e.g. *Palingenia longicauda*, amphibians etc.) and interrupted the lateral connectivity on several sectors of the channels also. Regarding the former Danube floodplain, upstream of the DDBR, these consisted in the construction of Iron Gates I and II which modified the dynamics of river sediments, interrupted the migration route of sturgeons and shads. At the same time, the construction of dams along the river interrupted the lateral connectivity and had as result the loss of natural habitats on a surface of about 500,000 ha (currently, agricultural polders). By dredging the canals more water, sediment and nutrients are currently reaching the interior of the complexes. Since the 1920s, the residence time of water has decreased by a factor 4 – 12, the sediment input has doubled and the nutrient input has increased by a factor of up to 16). (OOSTERBERG *et alii*, 2000). In this respect, the water discharges of the Danube River have a great impact on the habitats and the overall ecological status of the delta. Flooding and droughts are important water resources issues, both of which have occurred more frequently and with greater intensity in the last few decades, contributing to the degradation of inner delta and coastal ecosystems. (O'REGAN *et alii*, 2007; POPESCU *et alii*, 2015).

On the other hand, enhancing the navigation on the inner delta's channels through dredging and regulation by the storage of dredged sediments on the banks, the historic floodplain visualized as a line of submersed trees and bushes which define the location of the banks during flood periods has been permanently altered. The presence of artificial levees along the channels contributes to increasing current velocities and water inflow with the associated sediment into the lakes and changing the diversity of shoreline vegetation (hydrophytes: submerged, free floating and floating leaved plants; halophytes:

all rooted emergent and amphibious plants) which have an important role in trapping the sediments and pollutants. The floodplain lakes on both sides of the inner delta's channels faced a drastic modification in depth, especially in the upstream delta (Sontea – Fortuna wetland). Over the last 50 years, flooding and water circulation from Danube main branches into the channels network with reversible flow and intermittent flooding increased the inflow average of water input from approximately 260 m^3/s at around 1951 to 620m^3/s in the 1960-1990 period, contributing to the eutrophication process, which was much earlier visible in lakes than in canals or Danube branches (GÂȘTESCU, ȘTIUCĂ, 2006; OOSTERBERG *et alii,* 2000; POSTOLACHE, 2006). Changes were linked to the reduction in N:P ratio and impaired of the light conditions in the water (VĂDINEANU *et alii*, 1992; VĂDINEANU, 2001) which led to changes in the ecological succesion of phytoplankton (VĂDINEANU *et alii*, 1992, SANDU, 2006, COOPS *et alii,* 2008; TÖRÖK, 2014), a successful development of the submerged macrophytes species with vertical growth strategy (*Potamogeton pectinatus* and *P. trichoides*) which replaced the species with upright growth strategy (VĂDINEANU *et alii*, 1992), a structural and functional changes of macrozoobenthos and the decline of the benthivorous fish species diversity, the fish stocks and fisheries (VĂDINEANU *et alii*, 2000). By using Sobek hydraulic model, it has been emphasized the Danube Delta has an important role in the nutrient inputs of the Danube River water into the Black Sea (SUCIU *et alii*, 2002). The differences in the nutrient concentration input of the water into the delta and the concentration of the nutrients in the inner delta showed that delta acts like a bypass for the nutrients in the main branches of the river and like a filter in the lakes, swamps and marshes, retaining Nt in any hydrological condition but releasing P(P04) (CRISTOFOR *et alii*, 1993, SUCIU *et alii*, 2002).

Damming rivers changes sediment and nutrient cycles downstream of a dam in many direct and indirect ways (FRIEDL *et alii,* 2004). Researchers pointed to that inside of Iron Gate I nutrient remobilization from older sediments through early digenesis seems to remobilize nutrients deposited between 1970 and 1990, when nutrient loads in the Danube where 30% to 40% higher than today. The release from the sediment represents up to 47% of the present-day sedimentary nutrient accumulation, contributing to internal loading with 12%TN and 40% TP (TEODORU *et alii*, 2005). The nutrient retention in the Iron Gate I Reservoir represents only 1% (TEODORU *et alii*, 2005) but the remobilisation from older sediments could represent a source of nutrient pollution in the Danube River. In the lower part of the Danube River, during 1980-1989 due to the anthropogenic inputs the total reactive phosphorus concentration grew by about 5.7 times and the N:P ratio lowered by 25-85 times. These modifications are enhanced by the reduction of the flood plain area along the river and its tributaries (VĂDINEANU *et alii*, 1992).

Eutrophication, global warming and hydraulic works on the Danube River worked together and synergistically and inevitably led to modification of ecological equilibrium in the Danube Delta. For example, in 2012, the Danube Delta Biosphere Reserve was affected by drought, with up to 56 km of silted canals, a reduction of the water surface, a reduction of the water depths in lakes and pools and an enhanced danger of eutrophication (***, 2014a).

Under increasing anthropogenic impact on the surface water bodies, already loaded with an excessive historical release of nutrients from intensive agriculture and extreme weather events it has been recorded an increasing trend of cyanobacteria blooms in the Danube Delta (TÖRÖK, 2014). Due to the hydro-morphological structure of the delta, to the release of sedimentary phosphorus and the opportunity of cyanobacteria to use nitrogen from atmosphere as a nutrient source, cyanobacteria have been spread in all available niches (TÖRÖK *et alii*, 2017)

The occurrence of high cyanobacteria biomass in phytoplankton communities coupled with low autotrophy to herbivores energy-transfer efficiency has an impact on water quality, which leads to changes, both at the bottom and the top of the food chains (MONCHAMP *et alii*, 2017).

Due to this fact (***, 2014b), the change of natural habitats continues as a direct or indirect threat, some of them visible or supported by funding:

- ✓ Drainage of wet meadows and change to arable land or grazing meadows, even supported with environmental funds;
- ✓ Riverbed development and destruction of alluvial ecosystems, even supported with environmental funds;
- ✓ Afforestation of low yield meadows and steppe habitats, sometimes excessively considered by the authorities to be “degraded land”;
- ✓ Destruction of brush vegetation to extend grazing areas or develop tourism;
- ✓ Abandonment of meadows and grasslands, especially in elevated, less accessible areas, to be invaded by forest vegetation;
- ✓ Fish poaching;
- ✓ Invasive species that can cause major loss of biodiversity.

Even more than that, aggregation of cyanobacteria-concentrated by wind activity could have high impact on aquatic biodiversity – considering its potential toxic effect which increases the risk of toxin related health problems – in resting or feeding areas of the wildlife protected species, if no action to mitigate their effect is taken.

Conclusions

Due to the strong linkage between the Danube Delta and the Danube River policymakers should exploit at local and regional level actions that can increase the institutional cooperation that is needed to mitigate the effect of cyanobacteria blooms and its potential toxic effect on aquatic diversity. Those actions must be address to reducing eutrophication for the entire Danube Basin.

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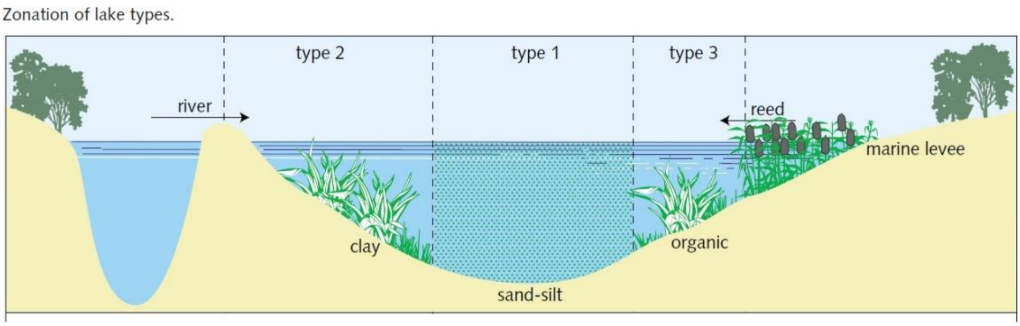

Figure 4. Types of lakes, after OOSTERBERG *et alii*, 2000.
Fig. 4. Tipuri de lacuri, după OOSTERBERG et alii, 2000.

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