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PHYTOPLANKTON BLOOMS OF THE DANUBE DELTA BIOSPHERE RESERVE

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Abstract: The phytoplankton is widely considered the most direct indicator of all the Biological Quality Elements. Due to the problems associated with increases of nutrients concentration and phytoplankton abundance in the water column, the assessment of the ecological status of aquatic ecosystems associated with increasing frequency and intensity of cyanobacterial blooms rises after the establishment of Danube Delta Biosphere Reserve the interest of governmental authorities. Its consequence was the development of a long term monitoring program of water quality. The results of this program provide information on phytoplankton blooms across the reservation and trends of bloom evolution in 15 lakes.

Key words: phytoplankton bloom, Danube Delta Biosphere Reserve

Introduction

The overwhelming effects due to the eutrophication pressures across Europe since the early1980s [1, 6, 7, 8, 9] determine the elaboration of a new legislative program concerning the sustainable management of the water resources. The Water Framework Directive (WFD) outlines the feature of ecological quality status of surface water bodies [3]. This provides overview guidance on methods for the assessment of water quality. In spite of these, there is no agreed limit for defining an algal bloom. Different countries use a variety of thresholds based on measures of phytoplankton abundance or biomass, cyanobacteria abundance, chlorophyll-*a* concentrations or amount of toxins [5, 13, 16].

The present paper provides information on how and where the bloom of phytoplankton appears in the Danube Delta Biosphere Reserve.

Materials and Methods

In order to evaluate the evolution of the "planktonic bloom" in aquatic ecosystems of the Danube Delta Biosphere Reserve there were used information form the literature [2, 9, 10, 11, 12, 14, 17] and the present author data from the investigations carried out during two periods, namely 1997-1998 and 2001-2006, in 15 lakes (Cuibul cu Lebede, Erenciuc, Fortuna, Iacub, Isac, Miazăzi, Merhei, Nebunu, Roşu, Roşuleţ, Uzlina, Razim, Sinoe, Somova and Rotund).

The feature of the planktonic bloom has been expressed by phytoplankton composition, abundance, frequency and intensity of blooms. The previously developed threshold of blooming and phytoplankton measurements [14] based on the proportion of diatoms and cyanobacteria has been used for evaluation of bloom type. Furthermore, due to a high variation, a given dominant species during the investigation period there was necessary to make differentiation inside of the dominant group. For a better representation, the dominant species [6] were split into three variation classes:

1. species having more than 50% of the total density
2. species having 25-50% of the total density and
3. species having 5-25% of the total density.

Further more, these species were included into three levels of dominance according to their frequency as follows:

1. D_1 – dominant species corresponding to frequencies higher than 25%
2. D_2 – dominant species corresponding to frequencies between 5 to 25%
3. D_3 – dominant species corresponding to frequencies below than 5%

In order to express the intensity of phytoplankton blooms according to WFD requirements there have been established as measure the proportion of cyanobacteria from the total phytoplankton abundance as follow:

1. cyanobacteria represent more than 50% of the total of phytoplankton
2. cyanobacteria represent about 25-50% of the total of phytoplankton
3. cyanobacteria represent about 10-25% of the total of phytoplankton

Results and Discussion

One problem with blooms occurrence in the Danube Delta lakes after the establishment of the Danube Delta Biosphere Reserve is that it cannot easily be recorded and estimated due to the high number of lakes (479 lakes according to Gâștescu et al., 1999) and low number of long term studies. Only in the case of three of them (Roşu, Uzlina and Isac) have been published reliable data obtained from studies carried out during more than five years [2].

The first blooms in the Danube Delta lakes associated with increase in phytoplankton abundance, particularly due to the increase of nutrient pressure, was recorded by Oltean and Nicolescu from 1980 [9, 10]. The assessment of nutrient variation reveals a dynamic change in the trophic level of the lakes [12, 14]. As nutrient concentrations increased, the ratio between cyanobacteria and other phytoplankton algae has been changed. The dominance and abundance of large colonial and filamentous cyanobacteria increased [2, 17].

In the published literature there are several contradictory data concerning the quantitative size of phytoplankton community from the Danube Delta lakes. According to, Cărăuş and Nicolescu [2] the phytoplankton abundance of the Roşu, Roşuleţ, Merhei and Isac Lakes, during 1992-1999 ranges only between 607-11687ind. l^{-1} in spite of a recorded biomass of 2.622 – 119.97 mg l^{-1}. On the other hand, in the case of other two lakes (Erenciuc and Gorgoştel) with quite similar phytoplankton composition the phytoplankton abundance during 2002-2004 ranges between 437 -5780000 ind. l^{-1} with a recorded biomass of 5.754-16.066 mg l^{-1} [17]. Taking into account these aspects the author supposed that the value recorded during 1992-1999 could be incorrect due to the typing mistakes (instead of, e.g. 11687 ind. l^{-1} probably is 11687000 ind. l^{-1}).

Due to the high variety of the aquatic ecosystems the dominant species of the phytoplankton community include besides cyanobacteria (e.g. *Aphanizomenon flos-aquae*, *Oscillatoria limosa, O. minima, O. tenuis*) also, green algae (e.g. *Chlorella vulgaris*) and diatoms (e.g. *Aulacoseira (Melosira) granulata, Asterionella formosa Cyclotella meneghiniana, C. operculata, Diatoma tenuis, Fragilaria capucina, Synedra (Fragilaria* or *Ulnaria) ulna, Staurosira beroliensis, Staurosira construens, Stephanodiscus hantzschi*) [2, 15, 17]. The phytoplankton is dominated by diatoms in spring. Cyanobacteria increase their abundance after June and blooms usually occur at the same time with diatoms [15].

Studies carried out during the present author's own investigations show that in 53.26 % of the cases the density of algae exceed the threshold of bloom ($14 * 10^5$ cells l^{-1}) [14] in the lakes of the Danube Delta. In 20.60% of the cases the dominant algal group was represented by diatoms and in 32.16% of the cases by cyanobacteria. In Uzlina lake, only in one case (June 2002), there was recorded that cryptophytes (73.62% of the total phytoplankton density) were dominants during the bloom period.

Based on the occurrence of blooms the most affected aquatic ecosystem of the Danube Delta Biosphere Reserve is the Razim lake, in which during the whole investigated period the density of algae exceeded the threshold of bloom. High frequency of blooms has also been

recorded in the Roşuleţ (83.33% of the cases), Sinoe (81.25% of the cases) and Roşu (80% of the cases) lakes.

During the investigated period there was recorded somewhat similar bloom frequencies but of different algal type, in case of Merhei (usually blooms with cyanobacteria) and Uzlina (usually blooms with diatoms); Miazăzi (usually blooms with cyanobacteria) and Nebunu (usually blooms with diatoms); Iacub (usually blooms with diatoms) and Rotund (usually blooms with cyanobacteria). The same pattern and bloom frequency was recorded only in the Erenciuc and Isac lakes (blooms with cyanobacteria).

Based on the level of incidence of cyanobacterial blooms in the Danube Delta Biosphere Reserve lakes the most affected ones (Fig. 1) were: Somova (100%), Rotund (87.5 %), Erenciuc (86.6 %), Sinoe (84.61 %), Razim (83.33 %) and Merhei (76.47 %) of the recorded cases.

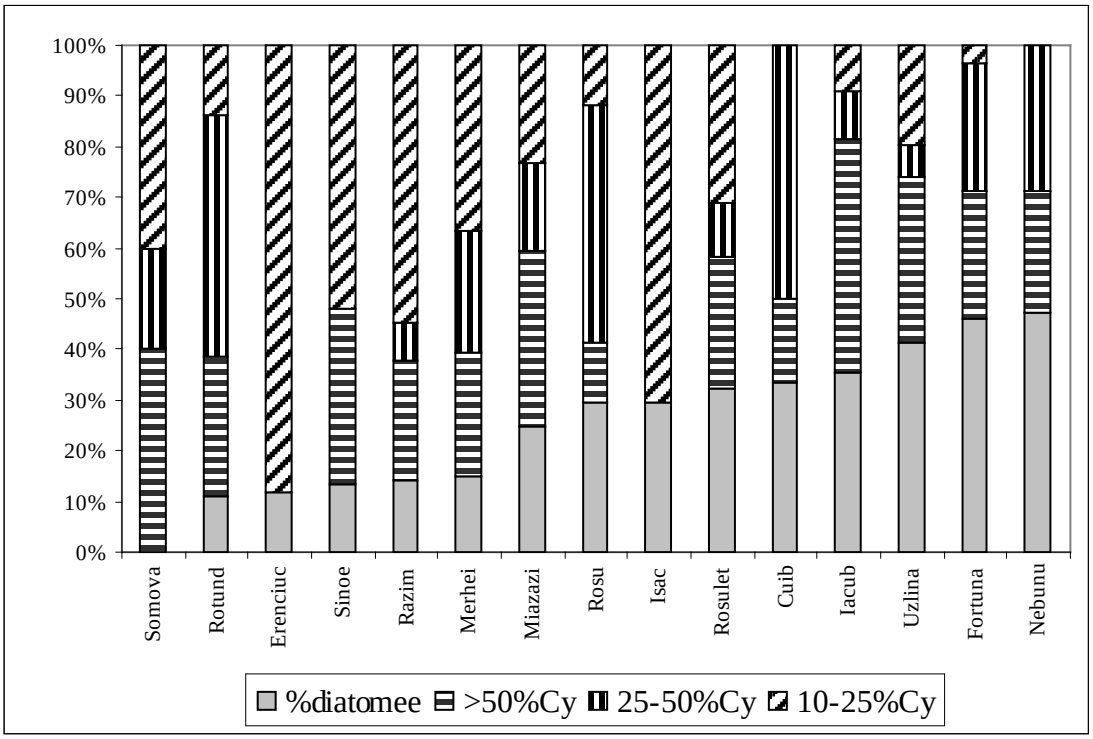

Fig. 1: Comparative analysis of the type and frequency of blooms in the lakes of the Danube Delta Biosphere Reserve. Note: Cy = cyanobacteria, diatomee = diatoms

The less affected lakes by cyanobacteria blooms are those which are located at a short distance from the Danube River, as in case of: Nebunu (10 %), Fortuna (14.28 %), Uzlina (23.52 %) of the recorded observations.

During 2001-2006 the highest value of recorded algae density (812 $*10^5$ ind. l^{-1}) was recorded in September 2001 in the Rotund Lake belonging to the Predeltaic zone of the Danube Delta Biosphere Reserve.

The trend of algal density development had a decreasing tendency in the last three years in some of the lakes (Merhei, Erenciuc and Miazăzi) of the Danube Delta. The occurrence of dense cyanobacteria bloom is not so frequent, possible due to the increase of water discharge flowing through the delta in the summer period caused by the recurrence of floods.

The aquatic ecosystems of the Danube Delta Biosphere Reserve are very diverse and dynamic [11]. Such a variety is confirmed by the occurrence of the 1098 species of algae reported only inside the delta [2]. Besides, the high species diversity of algae the studies reveals that the number of dominant species is relatively low.

The analyses performed in 15 lakes during the "bloom" period on the species diversity show that from the total number of recorded species (477 species) only 77 species are dominant and their development was very dynamic in time.

As a result, a model based on frequency of the dominant species could be developed for a better characterization of the phytoplankton blooms. According to this model, the dominant species has been classified into three frequency levels: D_1, D_2, and D_3. The widespread dominant species found during the bloom period are:

- diatoms - *Aulacoseira granulata* (D_1), *Asterionella formosa* (D_2), *Cyclotella meneghiniana* (D_2), *Fragilaria* (*Staurosira*) *construens* (D_2), *Fragilaria ulna* (D_2),
- cyanobacteria - *Anabaena circinalis* (D_2), *Lingbya limnetica* (D_2), *Oscillatoria limnetica* (D_3), *Microcystis aeruginosa* (D_3)

The author's own studies carried out during the investigation period revealed that there are also other species which contributed occasionally with higher density to the bloom-threshold:

- cryptophytes - *Cryptomonas erosa* (D3),
- crysophytes - *Dynobryon divergens* (D3),
- cyanobacteria - *Aphanizomenon flos-aquae* (D3), *Chroococcus microscopicus* (D3),
- green algae - *Chlorella vulgaris* (D3),
- diatoms *Fragilaria* (*Staurosira*) *beroliensis* (D3), *Stephanodiscus binderanus* (D3), *S. hantzschii* (D3).)

Based on the occurrence of blooms a cluster analyses has been performed on the Danube Delta Biosphere Reserve lakes (Fig. 2).

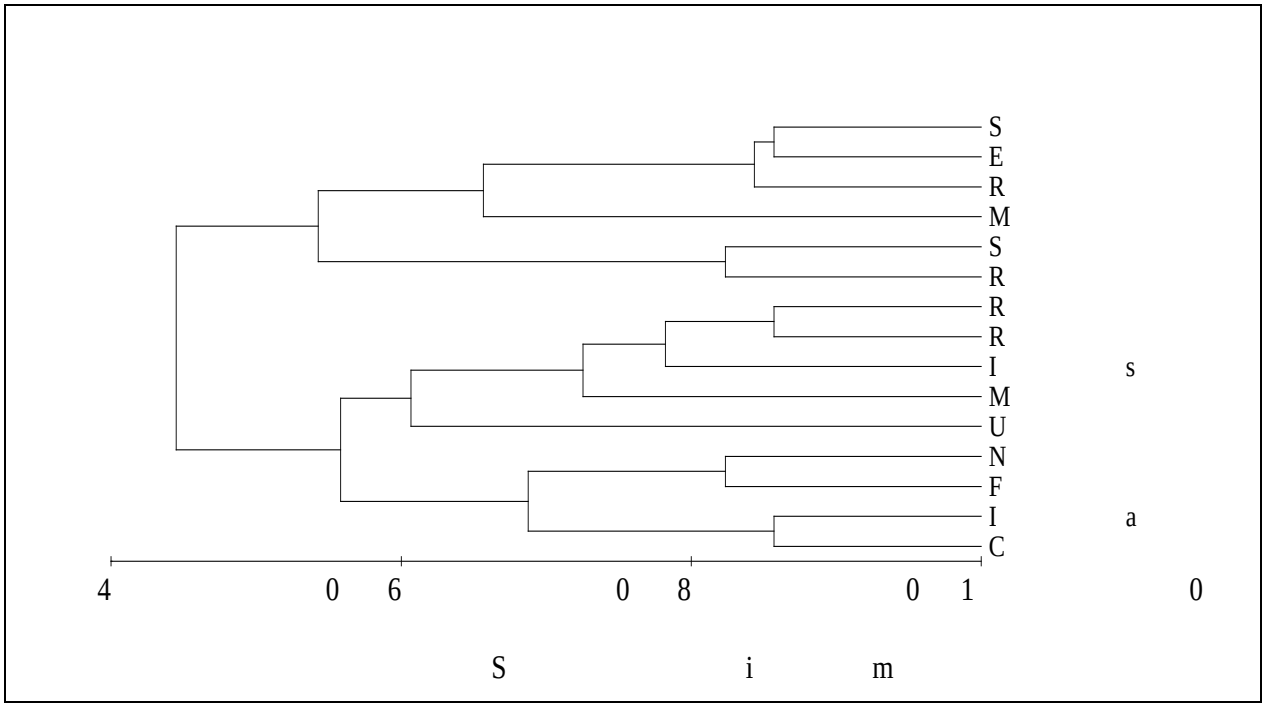

Fig. 2: The similarity between Danube Delta Biosphere Reserve lakes based on the frequency of blooms types

The results show that the lakes with similar characteristics are grouped together. Due to their proximity and strong hydrological relationship Roşu and Roşuleț lakes has a very high level of similarity. However, a short distance between lakes is not a rule for having the same bloom pattern (e.g. in case of the Uzlina and Isac lakes). The strong influence of the Danube River on the Uzlina lake induced different amplitude of phytoplankton development.

Due to the large year to year variation in phytoplankton dynamics the attempt of including the lakes of the Danube Delta in a rigid scheme of classification is very hazardous. Lakes as Cuibul cu Lebede, previously included in the same category with lakes with very good ecological status [11], has an ascending trend of phytoplankton development. The frequency of blooms increases showing high similarity with a type II lake (Iacub lake).

The high similarity between Erenciuc and Sinoe lakes on one hand and the position of the Miazazi lake in the similarity scheme on the other, namely separately from the lakes of the delta, shows how unforeseen function the whole systems.

Conclusion

A long term investigation shows that analysis based only on phytoplankton development could not reveal a strict boundary line between the categories of lakes established by the previous lake typology. The similarity between lakes based on phytoplankton blooms pattern is very high. During the investigation period the frequency of phytoplankton blooms decreases in the Danube Delta Biosphere Reserve lakes.

REFERENCES

1. Cărăuş, I., 1981, Aspecte ale conţinutului conceptului de eutrofizare. Trav., *Station Stejarul-Limnol*., **9**: 1-16.
2. Cărăuş, I., Nicolescu, I., 2006, Phytoplankton and its primary production. In: Tudorancea, C., Tudorancea M., (eds.) *Danube Delta Genesis and Biodiversity*, Backhuys Publishers., Leiden: 105-132.
3. Carvalho, L., Lepistö, L., Rissanen, J., Pietiläinen, O-P., Rekolainen, S., Török, L., Solheim, A.L., Saloranta, T., Ptacnik, R., Tartari, G., Cardoso, A.C., Permazzi, G., Gunn, I., Penning, E., Hanganu, J., Hellsten, S., Ibram, O., Năvodaru, I., 2006, Nutrients and eutrophication in lakes. In: Solimini, A. G., Cardoso, A.C., Heiskanen, A-S., 9eds.) *Indicators and methods for the ecological status assessment under the Water Framework Directive-Linkage between chemical and biological quality of surface waters*, EUR22314EN, Luxemburg: 3-33.
4. Gâştescu, P., Oltean, M., Nichersu, I., Constantinescu, A., 1999, Ecosystems of the Romanian Danube Delta Biosphere Reserve, *RIZA werkdocument 99.032x*: 1-33, The Netherlands.
5. Goldman, Ch.R., Horne, Al.J., 1983, *Limnology*, McGraw-Hill, U.S.A.: 1-464.
6. Gomoiu, M.T., Skolka, M., 2001, *Ecologie – Metodologii pentru studii ecologice*, Ed.Ovidius University Press, Constanţa: 1 – 170.
7. Krokowski, J., Jamieson, J., 2002, A decade of monitoring and management of freshwater algae in particular cyanobacteria, in England and Wales, *Freshwater Forum*, U.K., **18**: 3-12.
8. Moss, B.D., Alvarez, S.C., Becares, E., van de Bund, W., Collings, S.E., van Donk, E., De Eyto, E., Feldmann, T., Fernández-Aláez, C., Fernández-Aláez, M., Franken, R.J.M., Garía-Criado, F., Gross, E.M., Gyllström, M., Hansson, L-A., Irvine, K., Järvalt, A., Jensen, J-P., Jeppesen, E., Kairesalo, T., Kornijów, R., Krause, T., Künnap, H., Laas, A., Lill, E., Lorens, B., Ott, H.I., Peczula, W., Peeters, E.T.H.M., Phillips, G., Romo, S., Russell, V., Salujõe, J., Scheffer, M., Siewersen, K., Smal, H., Tesch, C., Timm, H., Tuvikene, L., Tonno, I., Virro, T., Vincente, E., Wilson, D., 2003, The determination of ecological status in shallow lakes - a tested system (ECOFRAME) for implementation of the European Water Framework Directive, *Aquatic Conservation: Marine and Freshwater Ecosystems* U.K., **13**, (6): 507-549.
9. Oltean, M., 1985, Troficitatea fitoplanctonică a ecosistemelor acvatice, *Bazele biologice ale proceselor de epurare şi Protecţia mediului,* Piteşti: 230-237.
10. Oltean, M., Nicolescu, N., 1985, Modificări în dezvoltarea fitoplanctonului din Complexul Matiţa-Merhei, *Delta Dunării Stud. Comun. Ecol*., Tulcea **1**: 193-196.
11. Oosterberg, W., Buijse, A.D., Coops, H., Ibelings, B.W., Menting, G.A.M., Staraş, M., Bogdan, L., Constantinescu, A., Hanganu, J., Năvodaru, I., Török, L., 2000, *Ecological gradients in the Danube Delta lakes. - Present state and man-induced changes. RIZA rapport* 2000.015, The Netherland: 3-168.
12. Porumb, M., David, C., 1994, Complexul Matiţa-Merhei indicatori de eutrofizare, *Analele IDD*, Tulcea, **III** 2: 357-362.
13. Török, L., 2005, How the algal bloom is defined and quantified in Europe today? *Analele IDD*, Tulcea, **XI**: 108-111.
14. Török, L., 2005a, Ecological status of the Danube Delta Biosphere Reserve's lakes, *Analele IDD*, Tulcea, **XI**: 112-115.

15. Török, L., 2005b, Seasonal succesion of phytoplankton from lakes of the Danube Delta, *Acta Oecologica*, Sibiu, **XII**: 15-23.
16. Török, L., 2006, Tehnici de monitoring şi evaluare a înfloririlor algale, *PETARDA*, Tulcea, **13**: 1-24.
17. Zinevici, V., Ionica, D., Parvală, L., Sandu, C., Muşa, R., Dobre, D.S., 2006, *Diversitatea unor comunitati de organisme acvatice in sisteme ecologice din zonele Erenciuc şi Gorgostel (Delta Dunarii)*, Ars Docendi, Bucureşti: 9-302.

ÎNFLORIRILE ALGALE ÎN REZERVAȚIA BIOSFEREI DELTA DUNĂRII

(Rezumat)

Dezvoltarea excesivă a fitoplanctonului a devenit o problemă majoră la nivel european încă de la începutul anilor 1980. Accentuarea efectelor cauzate de eutrofizare au fost resimțite şi la nivelul ecosistemelor acvatice din Delta Dunării, motiv pentru care a apărut necesitatea unor studii care să urmărească în mod sistematic apariția înfloririlor algale în aceste ecosisteme.

Date din literatura de specialitate, dar mai ales date provenite din investigațiile proprii efectuate timp de 8 ani în 15 lacuri amplasate în delta prorpri-zisă dar şi în avendeltă şi complexul lagunar Razim-Sinoe au permis întocmirea unui tablou sintetic al modului în care a evoluat acest fenomen după ce a fost înființată Rezervația Biosferei Delta Dunării.

Rezultatele referitoare la frecvența şi intensitatea cu care apar înfloririle în lacurile amplasate pe teritoriul Rezervației Biosferei Delta Dunării arată că în 53,26% din probele analizate densitatea numerică a fitoplanctonului a depăşit valoarea pragului de înflorire algală de 14×10^5 ind. l^{-1}

În ecosistemele acvatice ale Rezervației Biosferei Delta Dunării există două tipuri de înfloriri algale (cu cianobacterii şi cu diatomee). Înfloririle algale s-au datorat diatomeelor în 20,60% din cazuri şi cianobacteriilor în 32,16% din cazuri. Frecvența înfloririlor algale la nivelul întregii delte are o tendință descrescătoare în ultimii ani. Analiza similarității pe baza tipului şi frecvenței înfloririlor a permis stabilirea faptului că evoluția fenomenului de înflorire algală în Rezervația Biosferei Delta Dunării este foarte asemănătoare între diversele ecosisteme acvatice.

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