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MACROPHYTES MAPPING AND SPATIAL HETEROGENEITY OF SOME PHYSICOCHEMICAL PARAMETERS IN OGNYANOVO RESERVOIR

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Abstract

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Longitudinal differences in physical and chemical parameters lead to a trophic gradient in the reservoirs. Marked differences in abiotic parameters and trophic response were observed between the riverine and the lacustrine part of Ognyanovo reservoir in relation to nutrients loading. Abundance and species composition of aquatic macrophytes were studied between 2009 and 2012. The observations at each sampling station are based on transect monitoring data. Strong influence of water level fluctuations and seasonal dynamics were observed, which emphasizes the problem of what the proper time is for macrophytes sampling in reservoirs to provide an adequate definition of the ecological state in the future. The gathered data are used to produce a map of the macrophytes distribution in the reservoir. Rapid spread of the invasive species *Elodea nuttallii* is described after it appeared in the reservoir. A multiple point of spreading of *E. nuttallii* is observed in relation to fishermen and recreational activities. The *E. nuttallii* range expansion is assessed by its maximum linear rate of spread.

Key words: macrophytes, mapping, Ognyanovo reservoir

Introduction

The reservoirs are characterized by increased residence time, temperature, stratification, and reduction in turbulence, by decrease in particles and turbidity, and an increase in autochthonous primary production (Friedl and Wüest, 2002). The variability and complexity of these changes are reflected in the water quality that is controlled by several factors, among which the interaction of the lacustrine zone with the catchment's area plays an important role (Wetzel, 1983; Carpenter and Cottingham, 1997). The existence of progressive physical, chemical and biological changes along the main axis of the reservoir frequently is reflected by corresponding changes in the littoral aquatic vegetation. Those spatial and temporal variations should be kept in mind when designing a monitoring program for aquatic macrophytes to provide a representative and reliable estimation of the quality of reservoir water. To accomplish this, a detailed knowledge on the distribution of macrophytes is required (Melzer, 1999; Schneider and Melzer, 2003). The picture is further complicated by the introduction and spread of species not native for the region. Such species can have different rates of dispersal into the reservoirs, and their detection can be delayed in time, which consequently can have influence upon the ecological assessment of the water body. The problem with the dispersal or future (re)introductions of macrophytes species is further complicated by recreational activities, such as fishing, boating, etc. The human factor can obscure the dispersal pattern in any reservoir, opening additional fronts of spread, and modifying the linear speed of spread (Mineur et al., 2010).

The aim of this work was to study the relationship between the physicochemical parameters and the macrophytes composition in Ognyanovo reservoir.

Materials and Methods

The data is collected from 17 sampling stations in Ognyanovo reservoir, near Elin Pelin town, western Bugaria. Additional data are presented for the main sampling station (Station 1, Figure 1) located at 100 m from the reservoirs dam.

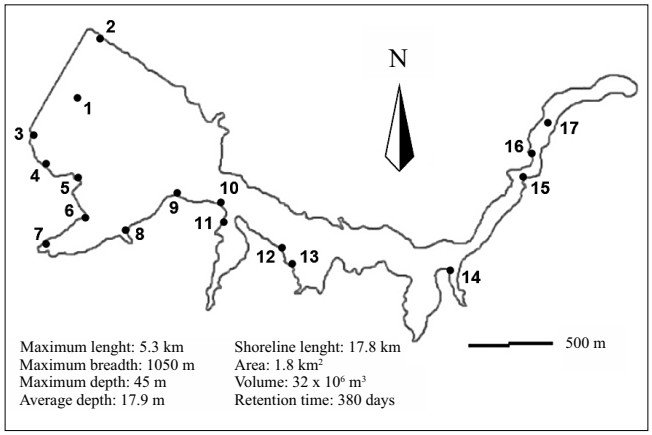

Fig. 1. Relative position of the sampling stations and the main morphometric characteristics of Ognyanovo reservoir

The aquatic macrophytes were collected between July 2009 and October 2012. Additional data about the physicochemical parameters are also available in Kozuharov et al. (2009), and hydrological data – from the Irrigation systems, LTD.

Onsite measurements and laboratory analysis of physicochemical parameters were conducted (total phosphorus and total nitrogen, chlorophyll-a, total alkalinity, as well as ammonium, nitrate and nitrite nitrogen concentrations and non-algal turbidity (NAT, m^{-1}) (Walker, 1985). The Carlson's trophic state indices were used to assess the trophic conditions in the reservoir (Carlson, 1977; Carlson and Simpson, 1996).

The empirical rate of spread of the invasive species *Elodea nuttallii* involved measurement of distance from the point of first observation. The maximum rate of spread method involved taking the location of the first date of observation in each area of the reservoir as the start of the invasion process. All subsequent observations were considered as potential measures of the invasive front (Mineur et al., 2010).

Results and Discussion

We present data on selected physical and chemical variables in the open waters (St.1) and in the near shore stations (St. 10 and St. 16) in Ognyanovo reservoir from 2009–2012.

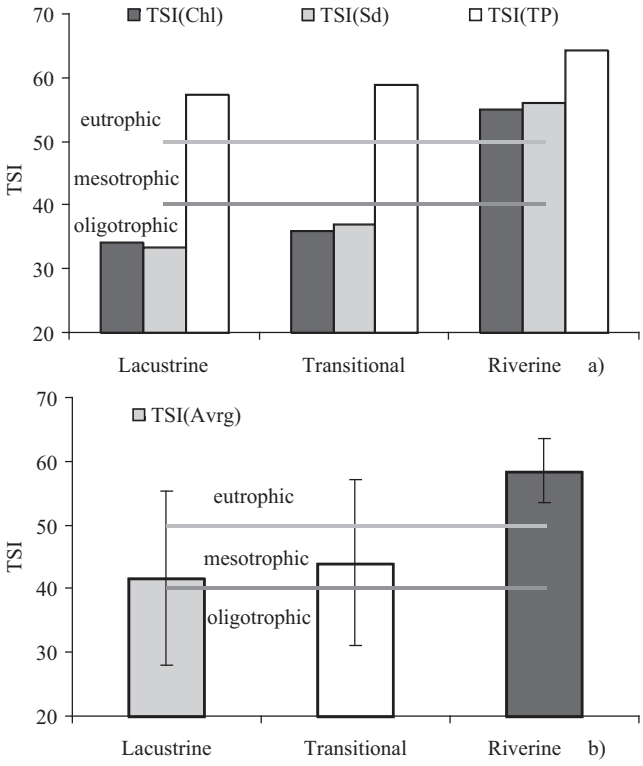

Fig. 2. Mean values of Chlorophyll-a, Secchi disc depth and Total phosphorus trophic state indices (TSI(Chl); TSI(SD) and TSI(TP), correspondingly) – a); AvrgTSI values for each zone in the reservoir – b). Vertical bars represent ± one standard deviation. Horizontal lines denote the boundaries between the major trophic classes

Table 1

Mean values of the physical-chemical parameters ± one standard deviation. Missing data is represented by n.a. Abbreviations used in the table are as follows: SD – Secchi disc depth; EC – electrical conductivity; DO – dissolved oxygen; TA – total alkalinity; TP – total phosphorus; TN – total nitrogen; Chl-a – chlorophyll-a; NAT – nonalgal turbidity

	SD m^{-1}	pH	EC µS/cm	DO mg/l	TA meq/l	TP mg/l	TN mg/l	PO_4-P mg/l	NO_3-N mg/l	NH_4-N mg/l	Chl-a µg/l	NAT m^{-1}
St.1/08-12	4.9 ±1.4	8.07 ±0.45	307 ±12	7.7 ±1.2	2.4 ±0.2	0.03 ±0.01	0.98 ±0.64	0.022 ±0.006	0.12 ±0.09	0.10 ±0.12	2.9 ±2.02	0.23 ±0.08
St.1/09-12	5.3 ±1.3	8.15 ±0.17	309 ±13	9 ±0.45	2.42 ±0.2	0.04 ±0.01	1.25 ±0.64	0.026 ±0.005	0.2 ±0.17	0.11 ±0.05	1.94 ±0.87	0.20 ±0.05
St.10/2012	5.2	8.38	314	8.8	2.5	0.03	0.8	n.a.	n.a.	n.a.	1.58	0.19
St.16/2012	1.3	7.42	353	11.8	2.9	0.06	1.2	n.a.	n.a.	n.a.	12.9	1.02

Table 2

Species composition at sampling stations in the reservoir

Growth form	Macrophytes	Stations according to fig. 1
submerged	*Ceratophyllum demersum* L.	2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17
	Chara spp.	2, 3, 4, 5, 6, 8, 10, 17
	Elodea canadensis Michx.	3, 4, 5, 7, 14, 15, 16, 17
	Elodea nuttallii St.John	3, 4, 5, 7, 8, 15, 16, 18
	Lemna minor L.	15, 16, 17
	Myriophyllum spicatum L.	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
	Myriophyllum verticillatum L.	3, 6, 7, 10, 12, 13
	Najas marina L.	6, 10
	Persicaria amphibia (L.) A.Gray	17
	Potamogeton crisps L.	17
	Potamogeton natans L.	4, 5, 17
	Potamogeton nodosus Poir.	2, 3, 4, 6, 8, 10, 11, 12, 15, 16, 17
	Potamogeton pectinatus L.	2, 3, 4, 5, 6, 9, 10, 12
	Potamogeton perforatus L.	5, 6, 8, 10
	Potamogeton pusillus L.	4
	Ranunculus trichophyllus Chaix	5
	Zannichellia palustris L.	17
emergent	*Alisma gramineum* Lej.	3, 4, 5, 7, 8, 10, 13, 17
	Alisma lanceolatum With.	2, 3, 4, 5, 6, 10
	Alisma plantago-aquatica L.	5, 15, 16
	Alopecurus aequalis Sobol.	3, 5, 7, 13, 15, 17
	Eleocharis acicularis (L.) Roem. & Schult.	3, 4, 8, 13
	Eleocharis palustris (L.) Roem. & Schult.	3, 5
	Equisetum palustre L.	17
	Iris pseudacorus L.	17
	Lycopus europaeus L.	3, 7, 17
	Lythrum salicaria L.	17
	Mentha aquatica L.	3, 5, 7, 17
	Persicaria hydropiper (L.) Delabre	3, 5, 7, 13, 17
	Phragmites australis (Cav.) Trin. ex Steud.	3
	Typha latifolia L.	2, 3, 5, 7, 13, 15, 17
	Veronica anagallis-aquatica L.	3, 17
	Veronica beccabunga L.	5, 7, 17

The data is compared to the available data set from 2008 to 2012 (Table 1). The relatively long retention time of the reservoir determines the strong spatial heterogeneity of the main physicochemical parameters, and the corresponding trophic state (Table 1, Figure 2). Although the physicochemical parameters of the reservoir are similar to the observed in most of the reservoirs in south-west Bulgaria (Traykov et al., 2010), Ognyanovo reservoir is characterized with much higher diversity of the aquatic macrophytes. A total of 33 species of aquatic macrophytes (17 submerged and 16 emergent) were found in the reservoir (Table 2, Figure 3).

Both species composition and abundance change throughout the vegetation season in relation to the lifespan of the species and the changes of the water level. Rapid spread of the invasive species *Elodea nuttallii* is described after it appeared in the reservoir. A multiple point of spreading of *E. nuttallii* is observed in relation to anglers and recreational activities.

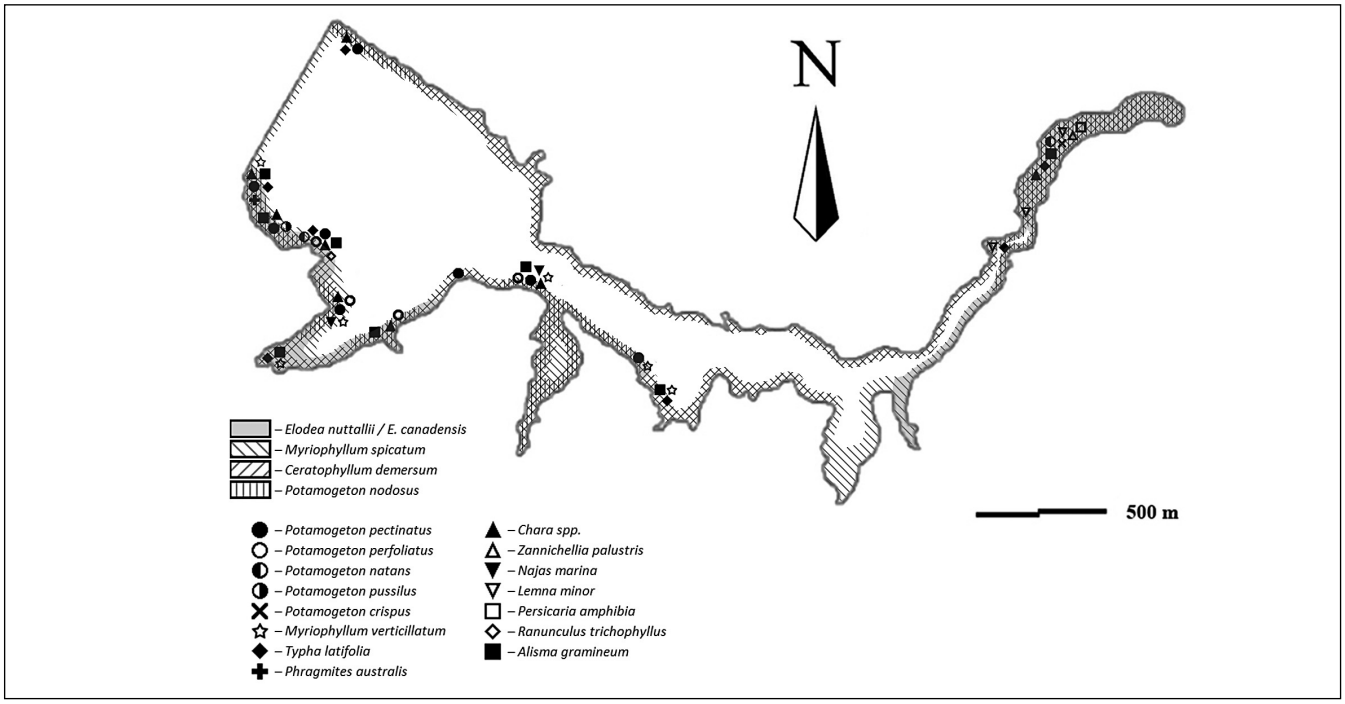

Fig. 3. Macrophytes distribution in Ognyanovo reservoir

Conclusion

The existence of strong spatial gradients of the physical and chemical parameters along the main axis of the reservoir is reflected by changes in the macrophyte composition and abundance. Events, like the lowering of the water table, influence the gradients of the physicochemical parameters and the abundance and vertical distribution of the macrophytes and can alter the overall assessment of the trophic state.

Since 2009 the invasive species *Elodea nuttallii* spread rapidly mostly at sites regularly visited for recreational activities. This multiple point of spreading of *E. nuttallii* determines its relatively high range expansion. Comparing the areas overgrown by the waterweed for the last 4 years, we were able to assess the linear rate of spread of *E. nuttallii*. The estimated rate is approximately 150–200 m yr^{-1}, suggesting that invasion started between 7 to 10 years ago.

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