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CONTRIBUTIONS TO THE KNOWLEDGE OF AQUATIC AND PALUDOUS MACROPHYTES AND OF SOME EPIPHYTIC ALGAE WITH ROLE IN PROCESSES OF SELF-CLEANING IN THE URBAN SECTOR OF NICOLINA RIVER - IASI

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Abstract. This paper brings a contribution to the knowledge of vegetal organisms that participate in the processes of self-cleaning in the urban sector of Nicolina river**.** By periodical outings on the field, observations on the field and in laboratory, we have identified species of aquatic and paludous macrophytes in the composition of water biocenosis of Nicolina river and algae taxons in the periphyton of some dominant or frequent aquatic and paludous macrophytes. We identified 28 species of superior macrophytes (paludous, aquatic); most of them are perennial species and prefer a sub-layer rich or excessively rich in mineral nitrogen. In the periphyton, the species of Phylum Bacillariophyta are predominant. The species taken into account fulfil numerous ecological services and are essential to assure the dynamic balance of the aquatic ecosystem.

Introduction

This paper is a continuation of our researches (Irimia et.al., 2014) regarding the knowledge of the biological characteristics of the Nicolina river in

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its lower course; this sector of the river faces some threats following some anthropic activities developed by the population of Iasi city.

The aquatic and paludous macrophytes are important components of the ecosystem of the running water. The presence and distribution of the species of macrophytes in the ecosystems of the running water depends on several factors: light, temperature, physic-chemical and chemical parameters of the water, quantity of nutrients, speed of water flow, depth of water, type of sub-layer, anthropic impact, etc. (Pârvu, 1999; Szoszbiewicz et al., 2006; Nikolic et al., 2009; Dar et al., 2014). Aquatic macrophyes present the capacity to accumulate large quantities of chemical elements useful for the vital processes or of heavy metals (Saygideger and Dogan 2004; Pavlović et al., 2005; Srivastava et al., 2008; Brankovic et al., 2012); they have a role of biofilters in the aquatic ecosystem and of bioindicators of the quality of the aquatic environment where they live (Pavlovic et al., 2005; Brankovic et al., 2012). Macrophytes represent a sub-layer for the communities of epiphytes organisms (attached) - periphyton. These communities are formed of bacteria, algae, fungi, protozoa, invertebrate organisms, as well as detritus (Wetzel, 2001 quoted by Špoljar et al., 2012). The epiphytes algae are considered good indicators of water quality and the changes in the aquatic environment, being sensitive to the high content of nutrients; they represent a source of food for consumers, in lakes, they contribute by around 40 % to the primary production (Karosienė and Kasperovičienė, 2008).

The purpose of this paper is to contribute to the inventory of the vegetal organisms with role in the processes of self-cleaning of the water in the urban sector of the Nicolina river - Iasi**.**

Materials and methodes

The Nicolina river is a right tributary of the river Bahlui; in was included in the national network of water quality monitoring, in the hydrographic basin Prut-Bârlad, beginning with 2009. The surface of the hydrographic basin is 117 km² and the length of the river is 20 km; the surface of the basin represents more than 8 % of the Bahlui river basin. (Minea, 2012). It flows into the Bahlui river on the territory of Iasi city.

The objectives of the paper were: identifying the species of aquatic and pond macrophytes in the water biocenosis of the Nicolina river (the course in the urban sector of the river); identifying some species of algae in the existing periphyton on species of frequent and dominant aquatic and paludous macrophytes; determining some physical - chemical parameters of water; underlining the importance in processes of self cleaning and other ecological services of the identified species.

To achieve the objectives set, we went on the field and for periodical observations on the field in the period autumn 2015 – summer 2017. At the location, we identified species of aquatic and paludous macrophytes. The river sector chosen for the study of the macrophytes was: neighbourhood CUG (former production halls of SC Fortus SA) until neighbourhood Galata. From the area of Galata and until the flow of the Nicolina river into the Bahlui river, the aquatic and paludous vegetation has been affected by works of stabilization/consolidation of the river bank. In May 2016, November 2016 and August 2017, we took samples to identify the species of algae in the periphyton and to determine some physical - chemical parameters of water in the three stations located in the area of the neighbourhoods CUG and Nicolina. The samples for the identification of the species in the periphyton were collected from the cormophytes *Sparganium erectum* ssp. *neglectum* (dominant) and *Potamogetum pectinatus* (frequent) and the green alga *Cladophora glomerata* (frequent). The examination of the periphyton was done from samples taken from the submerged part of the leaves at least 5 cm above the sediments and from filaments chosen from random variants of the alga *Cladophora glomerata* fixed on stony sub-layer. The samples were placed in bags of polyethylene, brought to the laboratory and kept in distilled water. The observations on algae were done on fresh preparations. Determining the species of superior macrophytes was done by direct observation, using the binocular magnifying glass and the determination of specialty published by Ciocârlan, (2000) and Sârbu et al., (2013). Determining the species of algae in the periphyton was done by using a microscope Novex and the determinations published by: Starmach, (1972, 1983); John et al.,(2002); Nagy-Tóth and Barna,(1998); Hindàk et al., (1978).

We determined the following physical and chemical parameters of water: pH and conductivity. The pH and conductivity were measured with a multi-parameter of Consort C532 type.

2. Results and discussions

2.1. Physical and chemical parameters of water

According to the data in tab.1, the water reaction is only slight alkaline. The average values of pH does not exceed the admissible maximum concentration (value 8.5) according to Order of Ministry 161/2006. It is an important indicator in estimating the water quality; it influences the life of aquatic organisms. *The conductivity* of the water samples presented high values (Table 1). Conductivity is one of the indicators used to appreciate the degree of water mineralization.

Table 1 Physico-chemical parameters of water (average±sd)

Month	Parameters	Sampling stations		
		Station 1	Station 2	Station 3
May 2016	pH	8.48±0.2	8.28±0.21	8.21±0.2
	Conductivity (μS/cm)	897±1	855.6±3.21	844±1
November 2016	pH	8.02±0.01	8.01±0.01	8.03±0.01
	Conductivity (μS/cm)	681±9.64	692.66±5.68	700.33±1.52
August 2017	pH	7.67±0.04	7.83±0	7.93±0.02
	Conductivity (μS/cm)	673±2	662±2	648.88±0.57

In the sector analysed, water presented a high degree of mineralization; conductivity is influenced mainly by the composition of rocks and the soils in the area crossed by the water. According to Pantazică (1974), the river waters in Bahlui basin present high mineralization (500mg/l - 1000mg/l) or very high mineralization (≥1000mg/l).

2. Taxons of vegetal organisms identified in the river sector analysed

a. Aquatic and paludous cormophytes

On the river sector analysed, we identified 28 species of cormophytes (paludous, aquatic) belonging to 19 botanical families; 13 species (46.42 %) are dicotyledonous and 15 species (53.57%) are monocotyledonous (Table 3). 88.8% of the species identified are perennial through the rhizome (Table 2). *Sparganium erectum ssp. neglectum* is dominant, occupying 90% of the sample surface. In the floristic list of the *aquatic macroscopic vegetal organisms* are also present species of macroscopic green algae: *Cladophora glomerata, Enteromorpha intestinalis* and *Spyrogira sp. Enteromorpha intestinalis* develops in the waters with high content of nitrogen and phosphorus, having the role to reduce the inorganic nitrogen to very low concentrations. More than 60 % of the species of superior macrophytes prefer a sub-layer rich or excessively rich in mineral nitrogen (Table 2). *Lemna minor* (duckweed – floating species) developed abundantly in several areas on the course of the Nicolina river (where depth was deeper and the flowing speed was very slow), especially in autumn.

Table 2 Characteristics of aquatic and paludous cormophytes

Species	Botanical families	Life cycle	Ecologic habitat type	Preference to the mineral nitrogen
Dicotyledonous				
Ceratophyllum demersum L.	Ceratophyllaceae	perennial	hydrophylous	+++
Ranunculus sceleratus L.	Ranunculaceae	annual	mesohygrophylous	++++
Ranunculus repens L.	Ranunculaceae	perennial	mesohygrophylous – hygrophylous	nitrophilous-tolerant

Polygonum hydropiper L.	Polygonaceae	annual	mesohygrophylous	++
Lythrum salicaria L.,	Lythraceae	perenial	hygrophylous	+++
Rorippa amphibia (L.) Besser	Brassicaceae	perennial	mesohygrophylous – hygrophylous	+++
Calystegia sepium (L.) R. Br.	Convolvulaceae	perennial	mesohygrophylous – hygrophylous	++++
Symphytum officinalis L.	Boraginaceae	perennial	mesohygrophylous	+++
Mentha aquatica L.	Lamiaceae	perennial	hygrophylous	++
Lycopus europaeus L.,	Lamiaceae	perennial	hygrophylous	+++
Lycopus exaltatus L.	Lamiaceae	perennial	hygrophylous	+++
Veronica beccabunga L.	Scophulariaceae	perennial	hygrophylous	++
Bidens cernuus L.	Asteraceae	anunal	hygrophylous	++++
Monocotyledonous				
Alisma plantago-aquatica L.	Alismataceae	perennial	hygro-hydrophylous	+++
Butomus umbellatum L.	Butomaceae	perennial	hygrophilous-hydrophylous	++
Potamogeton crispus L.	Potamogetonaceae	perennial	hydrophylous	+++
Potamogeton pectinatus L.	Potamogetonaceae	perennial	hydrophylous	+++
Iris pseudacorus L.	Iridaceae	perennial	hygrophylous	+++
Bolboschoenus maritimus (L) Palla	Cyperaceae	perennial	hygrophylous	++
Schoenoplectus lacustris, (L) Palla	Cyperaceae	perennial	hygrophylous	++
Agrostis stolonifera L.,	Poaceae	perennial	hygrophylous	+
Alopecurus aequalis Sobol.	Poaceae	perennial	hygrophylous	++++
Catabrosa aquatica (L.) P.Beauv.	Poaceae	perennial	mesohygrophylous – hygrophylous	+++
Glyceria fluitans (L.) R. Br.	Poaceae	perennial	hygrophylous	++
Agrostis stolonifera L.,	Poaceae	perennial	hygrophylous	+
Sparganium erectum ssp. neglectum L.	Sparganiaceae	perennial	hygrophylous	++
Typha latifolia L.	Typhaceae	perennial	hygro-hydrophylous	+++
Lemna minor L.	Lemnaceae	perennial	hydrophylous	+++
Legend: + prefers a poor substrate in mineral nitrogen; ++ prefers a substrate with moderate mineral nitrogen content; +++ prefers a substrate rich in mineral nitrogen; ++++ prefers a substrate excessively rich in mineral nitrogen				

Table 3. The taxonomic structure of the identified cormophytes

Class	No. species	No. genera	No. families
Dicotyledonous	13 (46,42%)	11 (44%)	10
Monocotyledonous	15 (53,57%)	14 (56%)	9
Total	28	25	19

a. Taxons of algae in the periphyton

The periphyton was examined from the samples taken from the dominant and frequent species: *Sparganium erectum* – dominant, *Potamogetum pectinatus* – frequent and *Cladophora glomerata* – frequent. *Cladophora glomerata* presents as small bushes, formed of distally branched filaments, fixed on the sub-layer (stones). *Potamogetum pectinatus* is a submerged species with branched stem, fixed on the sub-layer of the water basin. *Sparganium erectum* (bur-reed) presents young rhizome creeping, linear leaves (Ciocârlan, 2000); it can grow up to 1 m high, prefers the muddy sub-layer, rich in organic substances. The aquatic macrophytes can supply to the epiphyte algae both sub-layer and source of nourishment (Rogers and Breen 1981, quoted by Fawzi, 2016).

The taxons of algae identified belong to the phylums: Bacillariophyta, Cyanophyta, Chlorophyta and Euglenophyta (Table 4).

Table 4. Taxons of algae in the periphyton

	Species	May 2016	November 2016	August 2017	The saprobe categories*
1	**Bacillariophyta**				
2	*Achnanthes lanceolata* Grunow.		+/Clad.,		β
3	*Amphipleura pellucida* (Kützing) Kützing	+/Sp.,Pot.,	+/Pot.,Sp.	+/Sp.,	α - β
4	*Amphora ovalis* (Kützing) Kützing		+/Clad.,		α - β
5	*Asterionella formosa* Hassal	+/Sp.,			β
6	*Cocconeis placentula* Ehrenberg			+/Sp.,Clad.,Pot.	β
7	*Cyclotella compta* (Ehreb.) Kützing			+/Sp.,	
8	*Cyclotella meneghiniana* Kützing			+/Sp.,	β - α
9	*Cymbella affinis* Kützing		+/Sp.,		
10	*Cymbella lanceolata* Ehrenberg, Heiberg			+/Clad.,Sp.,	β
11	*Cymatopleura solea* (Brebisson) W. Smith		+/Sp.,Clad.,	+/Clad.,	β - α
12	*Diatoma vulgare* Bory			+/Sp.,Clad.,	β - α
13	*Fragilaria capucina* Desmazieres	+/Pot.,			β
14	*Gomphonema olivaceum* (Hornemann) Brebisson		+/Sp.,	+/Sp.,Clad.,Pot.	β - α
15	*Gyrosigma acuminatum* (Kützing) Rabenhors		+/Clad.,	+/Sp.,Clad.,	β
16	*Hantzschia amphioxys* (Ehrenberg) Grunow		+/Clad.,		α
17	*Melosira granulata*	+/Pot.,	+/Sp.,	+/Clad.,Pot.,S	β

	(Ehrenberg) Ralfs			p	
18	*Melosira varians* C.Agardh		+/Sp.,Clad.,		β
19	*Navicula cryptocephala* Kützing			+/Sp.,Pot.,	α
20	*Navicula exigua* Gregory			+/Sp.,	
21	*Navicula cuspidata* (Kutzing) Kutzing		+/Sp.,		β - α
22	*Navicula pupula* Kützing			+/Pot.,	
23	*Nitzschia sigmoidea* (Nitzsch.)W.Smith	+/Sp.,	+/Clad.,Sp.,		β
	Nitzschia sp.		+/Sp.,	+/Sp.,	
24	*Rhoicosphenia curvata* (Kützing) Grunow (Kützing) Grunow)		+/Clad.,	+/Sp.,Clad.,	β
25	*Rhopalodia gibba* (Ehrenberg) Otto Muller			+/Sp.,	β
26	*Stephanodiscus hantzschii* Grunow.		+/Sp.,		α
27	*Synedra acus* Kützing		+/Sp.,		β
28	*Synedra ulna* (Nitzsch)Ehrenberg	+/Sp.,	+/Sp.,	+/Pot.,Sp.,/Clad.,	α -p
29	*Surirella ovata* Kützing			+/Sp.,Clad.,	
	Cyanophyta				
30	*Anabaena catenula* Kützing ex Bornet & Flahault			+/Pot.,	
31	*Chamaesiphon sp.*			+/Clad.,	
32	*Lingbia kuetzingii* Schmidle			+/Clad.,	
33	*Oscillatoria brevis* Kützing ex Gomont			+/Sp.,	α
34	*Oscillatoria chalybea* Mertens ex Gomont			+/Pot.,	α
35	*Oscillatoria chlorina* Kützing ex Gomont			+/Pot.,Sp.,	p
36	*Oscillatoria limosa* Agard. ex Gomont		+/Sp.,	+/Pot.,Sp.,	β - α
37	*Oscillatoria princes* Vaucher ex Gomon			+/Clad.,Sp.,Pot.	
38	*Oscillatoria splendida* Greville ex Gomont			+/Pot.,	α
39	*Phormidium autumnale* Gomont			+/Clad.,	β - α
40	*Pseudanabaena catenata* Lauterborn			+/Sp.,	α-p
41	*Pseudanabaena limnetica* (Lemmermann) Komárek			+/Sp.,	
42	*Spirulina major* Kützing ex Gomont			+/Sp.,	
	Chlorophyta				
43	*Chlamydomonas sp.*			+/Sp.,	
44	*Kirchneriella lunaris* (Kirchner) Möbius			+/Sp.,	α
45	*Koliella corcontica* Hindák		+/Sp.,	+/Sp.,	
46	*Monoraphidium contortum*		+/Sp.,		

	(Thuret) Komárková-Legnerová				
47	Oedogonium sp.		+/Sp.	+/Pot.,	
48	*Scenedesmus quadricauda* (Turpin) Brébisson			+/Sp.,	β
49	Spyrogira sp.	+/Pot.,			
50	*Stigeoclonium tenue* (C.Agardh) Kützing			+/Sp.,Pot.,	
51	Tribonema sp.		+/Sp.,		
	Euglenophyta				
52	*Euglena polymorpha* P.A.Dangeard			+/Sp.,	α -p
53	*Euglena sp.*			+/Sp.,	
54	*Phacus pleuronectes* (O.F.Müller) Nitzsch ex Dujardin			+/Clad.,Sp.,	β - α
55	*Phacus pyrum* (Ehrenberg) W.Archer			+/Sp.,	
56	*Phacus tortus* (Lemmermann) Skvortzov			+/Sp.,	α

Legend: + the presence of the taxons, Sp. (*Sparganium erectum*), Pot. (*Potamogeton pectinatum*), Clad. (*Cladophora glomerata*), α (α mezosaprobic), β (β mezosaprobic), p (polysaprobic); * according to Sladecek, (1973) and Order of Ministry 161/2006

We identified 28 species and 20 genera of phylum Bacillariophyta, 13 species and 5 genera of phylum Cyanophyta, 6 species and 9 genera of phylum Chlorophyta, 4 species and 2 genera of phylum Euglenophyta (Table 5). During each of the three periods when the investigations were carried out, the taxonomic group of algae dominant of the species of macrophytes taken into consideration was that of the diatomaceous. We noticed the fact that in August the development in the periphyton and of the species of algae in the phylum Cyanophyta, Chlorophyta and Euglenophyta increased, registering the highest diversity of algae (42 taxons) (Table 4). This situation could be due probably to the seasonal modifications of the water temperature, the physical and chemical characteristics of water and the nutrient regime. The intense development of the community of epiphyte algae in August was reported by other authors as well: Karosienè and Kasperovičienè (2008), in epiphyte algae on *Phragmites australis,* in lakes. The development of the communities of epiphyte algae is influenced by several abiotic and biotic factors, such as: accessibility of nutrients, salinity, temperature, light, abundance of vegetation that represents a good habitat, etc. (Frankovich et al., 2006; Karosienè and Kasperovičienè, 2008).

The composition of algocenosis in the periphyton developed on the three macrophytes taken into consideration is different. Among all the taxons of algae identified, 20 are common in the periphyton of 3 species or only in 2 species of macrophytes taken into consideration; 24 taxons were identified only in the periphyton of *Sparganium erectum*, 6 taxons only in the periphyton of *Potamogeton pectinatum* and 6 taxons only in the periphyton of *Cladophora glomerata.* The highest number of taxons of epiphyte algae was identified on *Sparganium erectum* (Table 4). The species of diatomaceous *Amphipleura pellucida* (Kützing) Kützing, *Melosira granulata* (Ehrenberg) Ralfs and *Synedra ulna* (Nitzsch) Ehrenberg were identified every month when the samples were collected.

The algae participate in the process of self-cleansing of the water, because they use in the vital processes different chemical elements dissolved in water, they produce oxygen by the process of photosynthesis and contribute to the mineralization of the organic substances (Gorlenko, 1990). Among the species of algae identified, many are considered to be bio-indicators of the water quality (Order of Ministry 161/2006, Sladecek, 1973). During the period taken into account, predominant were the species characteristic to zone β mezosaprobic – 13 species (37.14 %), followed in decreasing order by species characteristic to zone β-α mezosaprobic – 8 species (22.85 %) and to zone α- mezosaprobic – 8 species (22.85%) (Table 5).

Table 5. The taxonomic structure of the algae in the periphyton

Phylum	**No. species**	**No. genera**	**The saprobe categories/no. species**
Bacillariophyta	28 (49,12%)	20 (55,55%)	α -3 sp.; α - β -2 sp.; β - 12 sp; β - α -5 sp; α -p-1
Cyanophyta	13 (22,80%)	5 (13,88%)	α -3 sp.; β - α -2 sp; α -p-1; p-1 sp.
Chlorophyta	6 (10,52%)	9 (25%)	α -1 sp.; β -1 sp.
Euglenophyta	4 (7,01%)	2 (5,55%)	α -1 sp; β - α -1 sp; α -p-1
Total	51	36	α -8 sp.; α -b-2p; β -13 sp.; β - α -8 sp.; α -p-3 sp.; p-1 sp.

3. The role of the species of aquatic and paludous vegetal organisms

The species identified have important roles in the structure and functions of the aquatic ecosystem on the urban course of the Nicolina river, as follows:

a) The aquatic and paludous macrophytes contribute to maintaining the sediments on the bottom of the river, and together with the phytoplankton and algae from the periphyton, the form the group of primary producers. The net primary production made represents the source of food/energy for the food levels of the consumers. The dynamics of the primary production made by macrophytes is in direct relation with a series of factors such as the regime of light, temperature, composition of the sediments, depth of water, quantity of available nutrients (Rich et al., 1971, Vis et al., 2007, Shilla and Dativa, 2008, - authors quoted by Nikolic et al., 2009).

b) They contribute to water oxygenation, setting the circuit of the water, the absorption of the polluting elements in the water.

c) They influence the distribution and abundance of some species of live organisms (bacteria, algae, animal organisms) by the fact that they serve as habitat and food for them.

d) They fulfil a very important role in the self-cleansing of the water by eliminating the excess of nutrients in the water (especially nitrogen and phosphorous) and by freeing the oxygen produced by photosynthesis, necessary to the processes of decomposition of the organic matter. The quantity of nutrients accumulates depends on the capacity of using them and the biomass of the aquatic macrophytes; the submerged and floating macrophytes are efficient in using the nutrients, more comparing with the emersed macrophytes (Srivastava et al., 2008). Also, the submerged macrophytes present also other mechanisms by which they contribute to maintaining the water clean: use of bicarbonates, allelopathy, they offer refuge for species of cladocerans that are efficient consumers of phytoplankton (Srivastava et al., 2008).

e) They are important bio-indicators of the environmental conditions and the ecological changes in the quality of water.

f) Some species of macrophytes (*Alisma plantago-aquatica*, *Butomus umbellatus, Ceratophyllum demersum, Lemna minor, Lycopus europaeus, Lytrum salicaria, Roripa amphibia, Mentha aquatica, Sparganium erectum, Typha angustifolia)* are good at accumulating heavy metals and other polluting substances, contributing to the water cleansing (Saygideger and Dogan 2004; Pavlovic et al., 2005; Vardanyan et al., 2008; Brankovic et al., 2012).

Pursuant to Order 161/2006, two of the species of macrophytes identified are included on the list of bio-indicators characteristic to the ecological areas of a river (*Ceratophyllum demersum, Lemna minor)* and 5 species are included on the list of saprobiological indicators of water (*Cladophora glomerata* β-mezosaprobic, 2; *Lemna minor* β-mezosaprobic*, 2; Ceratophyllum demersum* β-mezosaprobic*,* 2*; Potamogeton pectinatus* β-mezosaprobic*, 2; Typha latifolia* L. β- mezosaprobic, 2).

Conclusion

The species taken into account fulfil the essential ecological services to assure the dynamic balance of the aquatic ecosystem. The diversity of the aquatic and pond vegetal organisms in the urban sector of the Nicolina river maintains the quality of the river water between the limits of the categories α-β-mezosaprobic and assure the stability of the aquatic and pond phytocenosis in possible pressure from some alien species that can reach at random the minor bed of the Nicolina river.

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