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CONTRIBUTION TO THE ALGAE, CYANOBACTERIA AND VASCULAR PLANTS OF THE "SZMARAGDOWE LAKE" IN THE KADZIELNIA RESERVE

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ABSTRACT. The paper presents a list of vascular plant, algae and cyanobacteria species recorded in 2008--2010 in the "Szmaragdowe Lake" and in its surroundings in the Kadzielnia Reserve in Kielce. A total of 238 taxa (including algae – 84 species, cyanobacteria – 22 species and vascular plants – 132) were identified. All taxa are briefly described and some ecological indicator values also analysed.

KEY WORDS: algae, cyanobacteria, vascular plants diversity, ecology, "Szmaragdowe Lake"

INTRODUCTION

The "Szmaragdowe Lake" situated in the middle part of bottom in the Kadzielnia quarry, which is a part of the Kadzielnia Range (the Świętokrzyskie Mountains) is located in Kielce (Figs 1, 2). According to Czarnocki (1958) and Wróblewski (1976, 2008) the limestone excavation, goes back to the turn of XVII/XVIII centuries. In 1962, the geological reserve, protection, was established in the part of quarry with a rocky hill top. In order to increase attractiveness of a new reserve, in the former deepest part of quarry (below the flood-water level), a water reservoir called by the people "Szmaragdowe Lake" was created (the name is after its characteristic tint of water). The colour of water is connected with the minerals presence – calcium carbonate derivatives, multicoloured calcite. In 1972-1974 the water level decreased because of drawing groundwater by wells, which were drilled in the Białogon Valley and Kielce and also as a result of a long-lasting drought. At the end of the 70's the Wodociągi Kieleckie (Kielce Waterworks System) ran water into the reservoir and thereby the "Szmaragdowe Lake" regained its former state back. The reserve is built from stromatopora and coral limestone, covered by marly-limestone. Both floristic (Drymmer 1890, Błoński 1892, Maciejczak and Bróż 1987, 1992, Maciejczak 1988, 2008, Bróż and Maciejczak 1991, Maciejczak and Rostański 1994, Maciejczak and Czerwik-Marcinkowska 2010) and phycological studies (Mrozińska and Czerwik 1996, Czerwik-Marcinkowska and Ziętarski 2011) have been carried out within the Kielce area. The aim of this study was to present biodiversity of 238 species of algae, cyanobacteria and vascular plants from the "Szmaragdowe Lake" in the Kadzielnia Reserve. These data will supplement the results concerning plants protection in the inactive quarry in Kielce.

MATERIALS AND METHODS

The field investigations of algae, cyanobacteria and vascular plants were conducted during 2008-2010. They included: reservoir water, the plants' zone from the point of water and stable substratum contact, and the area, which surrounds the reservoir from the water level 50-200 meters (it refers also to the height of pit cliffs). The research followed the generally accepted method of Braun-Blanquet (1964). Nomenclature of species was after Mirek et al. (2002) and phytosociological groups, life forms, and indicator values are presented according to Zając (1979), Zając et al. (1998), Zarzycki et al. (2002), Matuszkiewicz (2008), Wysocki and Sikorski (2009).

Water samples were taken regularly (once a month) with a plankton net and were preserved in 4% formalin solution. Material was also collected from the surface of stones and macrophytes. Ecological groups of diatoms in relation to trophy were defined after van Dam et al. (1994) and Lange-Bertalot (1996). Taxon identification and nomenclature was according to: Anagnostidis and Komárek (1989), Starmach (1989), Krammer and Lange-Bertalot (1991), Wołowski (1998), Hindák (2001), Wołowski and Hindák (2005).

RESULTS AND DISCUSSION

Basing on the study conducted in the "Szmaragdowe Lake" 238 taxa (including algae – 84 species, cyanobacteria – 22 species and vascular plants – 132), were

Fig. 1. View of the "Szmaragdowe Lake" in the Kadzielnia Reserve (Phot. J. Czerwik-Marcinkowska)

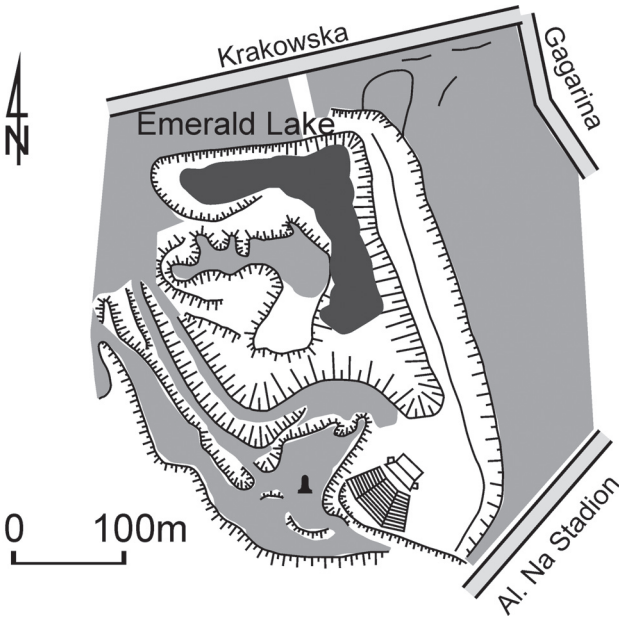

Fig. 2. Locality of the "Szmaragdowe Lake" in the Kadzielnia Reserve

identified (Table 1 and 2). They were found in water and near-water habitats, both in wet and dry places, in clefts, on stone shelves, as well as on small areas full of rock debris, with mixture of sand and other building materials used for management of the area. Trees and shrubs are representatives of permanently native species of vascular plants, which were implanted right after the exploitation was finished. The wind-dispersed plant species (*Betula pendula*, *Acer negundo*, *A. platanoides*, *Salix fragilis* with varieties) and zoochory species (*Berberis vulgaris*) must be also added to that representative group. A large concentration of the mentioned species was noticed in the north part of the pit, where the biggest part of the reservoir is located. The most numerous group were rhizomatous perennials: stoloniferous, tuberiferous, bulbous, which occurred in all of habitat types in the study area. In small hollows, which are periodically flooded, a group of therophytes were noted: *Bidentetea tripartiti* (*Bidens tripartita*, *Chenopodium glaucum*, *Ranunculus sceleratus*) and *Isoeto-Nanojuncetea* (*Juncus bufonius*, *Potentilla supina*). The perennials, which derived from different phytocoenosis, that appeared in the city area and in suburban zone, were recorded on sunny and warm stands. An interesting group of native species were xerothermic grassland communities (*Festuco-Brometea*), sandy grasslands (*Koelerio glauceae-Corynephoretea canescentis*) and thermophilous shrubs (*Trifolio-Geranietea sanguinei*), such as: *Acinos arvensis*, *Allyssum alyssoides*, *Artemisia campestris*, *Campanula glomerata*, *Centaurea stoebe*, *Cerastium arvense*, *Festuca ovina*, *Medicago falcata*, *M. lupulina*, *Origanum vulgare*, *Plantago media*, *Salvia vericillata*, *Sedum acre* and *S. reflexum*, *Veronica spicata*. Meadow species (*Molinio-Arrhenatheretea*) had great participation in studied flora, especially: *Alopecurus geniculatus*, *Bromus hordeaceus*, *Carum carvi*, *Centaurea jacea*, *Dactylis glomerata*, *Daucus carota*, *Ranunculus acris* and other recorded mainly on wet and ruderal habitats. A particular value have the following patches: *Agropyro-Rumicion crispi*, which tolerate saline habitats (*Carex hirta*, *Potentilla anserina*, *Potentilla reptans*, *Ranunculus repens*, *Rumex crispus*), and treading *Plantaginetalia majoris* (*Lolium perenne*, *Plantago major*), appearing in places under direct influence of human activities. Synanthropic communities

Table 1. List of vascular plant species found in the studied area

Taxa	Life forms	L	S	R	Phytosociological unit
1	2	3	4	5	6
Acer negundo L.	M	4	-	3-5	Sal purp
Acer platanoides L.	M	4	-	4	Que-Fag
Acinos arvensis Lam.	H, T	5	-	5	Fest-Brom
Agrimonia eupatoria L.	H	5	-	5	Fest-Brom
Agrimonia procera Wallr.	H	3-4	-	4	Trif-Ger
Alisma plantago-aquatica L.	Hy	4	1	4	Phragm
Alopecurus geniculatus L.	H	4	1	3-4	Agr-Rumi
Allium montanum F.W. Schmidt	G	5	-	5	Fest-Brom
Allyssum alyssoides L.	T	5	-	5	Sed-Scl
Arctium lappa L.	H	5	-	4	Arction
Arctium tomentosum Mill.	H	4	-	4	Arction
Arrhenatherum elatius L.	H	4	1	4-5	Arrhen
Artemisia absinthium L.	Ch	5	-	3-4	Onopord
Artemisia campestris L.	Ch	5	-	5	Fest-Brom
Artemisia vulgaris L.	H	5	-	4-5	Artemi
Asparagus officinalis L.	G	5	-	5	Fest-Brom
Asperula cynantchica L.	H	5	-	5	Fest-Brom
Asplenium ruta-muraria L.	H	4	-	4-5	Pot caul
Asplenium trichomanes L.	H	4	-	3-4	Asplen
Atriplex patula L.	T	5	1	4-5	Artemi
Berberis vulgaris L.	N	5	-	5	Fest-Brom
Berteroa incana L.	T, H	5	-	4-5	Onopord
Betula pendula Roth	M	4	-	5	Que rob
Bidens tripartita L.	T	5	-	4-5	Bident
Bromus hordeaceus L.	T	4	1	4-5	Arrhen
Calamagrostis epigeios L.	G,H	4	1	3	Epilob
Callitriche cophocarpa Sendtn.	Hy	4	1		Hottonion
Cardaminopsis arenosa Hayek	3	3	1	3-5	Mol-Arr
Campanula glomerata L.	H	4	-	4-5	Fest-Brom
Campanula patula L.	H	5	-	4	Faget
Campanula rapunculoides L.	H	4	-	4	Tri-Ger
Campanula sibirica L.	H	5	-	5	Fest val
Carex hirta L.	G	4	-	3-5	Agr-Rumi
Carum carvi L.	H	4	1	4	Arrhen
Centaurea jacea L.	H	4	1	3-4	Mol-Arr
Centaurea scabiosa L.	H	5	-	4-5	Fest-Brom
Centaurea stoebe L.	H	5	-	5	Fest-Brom

Table 1 – cont.

1	2	3	4	5	6
Cerastium arvense L.	C	5	-	3-5	Sed-Scl
Cerastium holosteoides Fr.	C, H	4	1	3-5	Mol-Arr
Chenopodium glaucum L.	T	5	1	4-5	Asteret
Cichorium intybus L.	H	5-4	1	3-5	Artemi
Consolida regalis Gray	T	5	-	5	Caucalid
Convolvulus arvensis L.	G, H	5	-	3-5	Fest-Brom
Conyza canadensis L.	T, H	5	-	3-4	Stel-med
Coronilla varia L.	H	5		4-5	Trif-Ger
Cystopteris fragilis L.	H	2-3		4-5	Asplen
Dactylis glomerata L.	H	4	1	4-5	Arrhen
Daucus carota L.	H	5	1	4-5	Arrhen
Dianthus carthusianorum L.	C	5		5-3	Fest-Brom
Elodea canadensis Michx.	Hy	4		4-5	Potamion
Elymus hispidus (Opiz.) Melderis	G	5		5	Ammoph
Epilobium hirsutum L.	H	4	1	5	Convol
Epilobium palustre L.	H	4	1	3	Aln glu
Equisetum arvense L.	G	4-5	1	3-4	Stel-med
Erigeron acris L.	H, T	5		4-5	Fest-Brom
Eupatorium cannabinum L.	H	3-4	1	4-5	Artemi
Falcaria vulgaris L.	H	5		5	Fest-Brom
Festuca ovina L.	H	4	1	3-5	Sed-Scl
Festuca pratensis Huds.	H	4	1	4	Mol-Arr
Fragaria vesca L.	H	3-4		3-4	Epilob
Fragaria viridis Duchesme	H	4-5		5	Epilob
Galium verum L.	H	5		5-4	Fest-Brom
Gentianella ciliata (L.) Borkh.	H, T	5		4-5	Fest-Brom
Geranium columbinum L.	T	5		4-5	Artemi
Glechoma hederaceae L.	G, H	4-2	1	4	Artemi
Glyceria fluitans (L.) R. Br.	Hy	4	1	4	Aln glu
Glyceria maxima (Hartm.) Holmb.	Hy	4	1	5	Phragm
Heracleum sphondylium L.	H	4	1	4-5	Arrhen
Jovibarba sobolifera (Sims) Opiz	C	4		4	Asplen
Juncus articulatus L. emend. K. Richt.	G, H	5	1	3-4	Sch-Car
Juncus bufonius L.	T	5		3-5	Iso-Nan
Juncus compressus Jacq.	G	4	1	4-5	Agr-Rumi
Juncus tenuis Willd.	H	4	-	3-4	Polyg avi
Lactuca serriola L.	H	5	-	5	Sisymbrion
Leontondon autumnalis L.	H	4	1	4	Cynosur
Lepidium ruderale L.	H, T	5	1	4	Sisymbr

Table 1 – cont.

1	2	3	4	5	6
Lolium perenne L.	H	4	1	4	Polyg avi
Lotus corniculatus L.	H	4	1	3-4	Arrhen
Lotus uliginosus Schkuhr	H	4	1	4	Mol caer
Lysimachia nummularia L.	C	3	-	4	Mol caer
Medicago falcata L	H	5	-	5	Fest-Brom
Medicago lupulina L.	H, T	5	-	3-5	Stel-med
Melandrium album (Mill.) Garcke	T, H	5	1	4	Artemi
Mentha aquatica L.	H, Hy		1	4	Phragm
Myriophyllum verticillatum L.	Hy	4	-	4-5	Nymphaeion
Nuphar lutea L.	Hy	5	-	4-5	Nymphaeion
Odonites serotina Lam.	T, pp	4	1	4	Mol-Arr
Origanum vulgare L.	C, H	4	-	5	Trif-Ger
Phalaris arundinacea L.	G, H	4	1	4-5	Phragm
Phragmites australis (Cav.) Trin. ex Steud	H, Hy	4-5	1	4	Phragm
Picris hieracioides L.	H	4	-	5-4	Fest-Brom
Pimpinella saxifraga L.	H	5	-	4-5	Fest-Brom
Plantago lanceolata L.	H	4	1	4	Mol-Arr
Plantago major L.	H	5	1	4	Polyg avi
Plantago media L.	H	4	2	5-4	Fest-Brom
Poa annua L.	H, T	5-3	-	5	Stel-med
Poa compressa L.	H	5	-	5	Fest-Brom
Poa palustris L.	H	4	-	4-5	Fest-Brom
Poa pratensis L.	H	4	1	4	Mol-Arr
Polygonum amphibium L.	Hy, G	4	1	5	Nymphaeion
Potamogeton lucens L.	Hy	4	1	5	Potamion
Potamogeton pectinatus L.	Hy	4	1	4-5	Potamion
Potentilla anserina L.	H	5	1	5-4	Agr-Rumi
Potentilla arenaria	H	5	-	5	Fest-Brom
Potentilla reptans L.	H	5	1	5-4	Agr-Rumi
Potentilla supina L.	H, T	5	-	4	Iso-Nan
Ranunculus acris L.	H	4	1	4-5	Mol-Arr
Ranunculus repens L.	H	4-5	1	4-5	Stel-med
Ranunculus sceleratus L.	T	5	-	4	Bident trip
Reseda lutea L.	H	5	-	4	Onopord
Rumex crispus L.	H	5	1	4	Stel-med
Salix fragilis L.	M	4	-	4-5	Sal purp
Salvia pratensis L.	H	5	-	5	Fest val
Salvia verticillata L.	H	5	-	4	Fest-Brom
Sanguisorba minor L.	H	5-4	-	5	Fest-Brom
Schoenoplectus lacustris (L.) Palla	G, Hy	3-4	-	-	Phragmition

Table 1 – cont.

1	2	3	4	5	6
Sedum acre L.	C	5	-	3-5	Asplen
Sedum reflexum L.	C	5	-	5-4	Coryneph
Seseli annuum L.	H	5	-	4-5	Fest-Brom
Silene vulgaris (Moench) Garcke	C, H	4	-	5-4	Asplen
Stachys recta L.	H	4	-	5	Fest-Brom
Typha latifolia L.	H, Hy	4	-	5-4	Phragm
Veronica spicata L.	H, C	4	-	4-5	Fest-Brom

Explanations:
Life forms: C – herbaceous chamaephyte, Ch – woody chamaephyte, G – geophyte, H – hemicryptophyte, Hy – hydrophyte, M – megaphanerophyte, N – nanophanerophyte, T – therophytes;
Indicator values: (L) – light value, 2 – moderate shade, 3 – half-shade, 4 – moderate light, 5 – full light; (S) – value of resistance to NaCl content in soil or water, 1 – species tolerating increased NaCl content, 2 – species growing mainly on soils with increased NaCl content; (R) – soil (water) acidity (pH) value, 1 – highly acidic soils, pH < 4, 2 – acidic soils, 4 < pH < 5, 3 – moderately acidic soils, 5 < pH < 6, 4 – neutral soils, 6 < pH < 7, 5 – alkaline soils, pH > 7;
Phytosociological unit: Agr-Rumi – *Agropyro-Rumicion crispi*, Aln glu – *Alnetea glutinosae*, Ammoph – *Ammophiletea*, Arction – *Arction lappae*, Arrhen – *Arrhenatheretalia*, Artemi – *Artemisietea vulgaris*, Asplen – *Asplenietea rupestria*, Asteret – *Asteretea trifolium*, Bident – *Bidentetea tripartiti*, Bident trip – *Bidention tripartiti*, Caucalid – *Caucalido-Scandicetum*, Convol – *Convolvuletalia sepium*, Coryneph – *Corynephoretalia canescentis*, Cynosur – *Cynosurion*, Epilob – *Epilobietea angustifolii*, Faget – *Fagetalia*, Fest-Brom – *Festuco-Brometea*, Fest val – *Festucetalia valesiaceae*, Hottonion – *Hottonion*, Iso-Nan – *Isoeto-Nanojuncetea*, Mol-Arr – *Molinio-Arrhenathereatea*, Mol caer – *Molinietalia*, Nymphaeion – *Nymphaeion*, Onopord – *Onopordon acanthi*, Phragm – *Phragmitetalia*, Phragmition – *Phragmition*, Polyg avi – *Polygonion avicularis*, Potamion – *Potamogetonetea*, Pot caul – *Potentilletalia caulescentis*, Que-Fag – *Querco-Fagetea*, Que rob – *Quercetea robori-petraeae*, Sal purp – *Salicetea purpureae*, Sch-Car – *Scheuchzerio-Caricetea nigrae*, Sed-Scl – *Sedo-Scleranthetea*, Sisymbrion – *Sisymbrion*, Stel-med – *Stellarietea mediae*, Trif-Ger – *Trifolio-Geranietea sanguinei*.

Table 2. List of algae and cyanobacteria species recorded in the "Szmaragdowe Lake" (ecological indicators values of freshwater diatoms acc. to van Dam et al. 1994)

Species	Present	R	H	N	O	S	T	M
1	2	3	4	5	6	7	8	9
Heterokontophyta/Bacillariophyceae								
Achnanthes lanceolata (Bréb.) Grun.	+	3	2	2	1	2	5	1
Achnanthes minutissima Kütz.	+	3	2	2	1	2	7	3
Amphora ovalis (Kütz) Kütz.	+	4	2	2	2	2	5	1
Anomoeoneis sphaerophora (Ehr.) Pfitz.	+	5	3	2	4	3	5	3
Asterionella formosa Hass.	+	4	2	2	2	2	4	1
Aulacoseira granulata (Ehr.) Sim.	+	4	2	3	2	2	4	1
Aulacoseira italica (Ehr.) Sim.	+	4	2	3	2	2	5	2
Caloneis amphisbaena (Bory) Cl.	+	4	3	2	3	3	5	3
Caloneis silicula (Ehr.) Cleve	+	4	3	2	3	2	5	2
Cocconeis placentula Ehr.	+	4	2	2	3	2	5	2
Cymatopleura solea (Bréb.) W. Sm.	+	4	2	2	3	2	5	1
Cymbella affinis Kütz.	+	4	2	1	1	2	5	2
Cymbella cistula (Ehr.) Kirchner	+	4	2	1	2	2	5	1
Cymbella cuspidata Kütz.	+	3	2	-	-	1	-	-

Table 2 – cont.

1	2	3	4	5	6	7	8	9
Cymbella lanceolata (Ehr.) Kirchn.	+	4	2	1	1	2	5	1
Denticula tenuis Ehr.	+	4	1	1	1	1	3	3
Diatoma vulgaris Bory	+	5	2	2	2	2	4	1
Diploneis elliptica (Kütz.) Cleve	+	-	-	-	-	-	-	-
Diploneis ovalis (Hilse) Cleve	+	3	1	1	1	1	2	3
Fragilaria ulna (Nitzsch) Lange-Bert.	+	4	2	2	3	4	7	2
Gomphonema acuminatum Ehr.	+	4	2	1	2	2	5	2
Gomphonema olivaceum (Horn.) Bréb.	+	5	2	2	2	2	5	1
Gomphonema parvulum (Kütz) Kütz.	+	3	2	3	4	4	5	3
Gyrosigma attenuatum (Kütz.) Rabenh.	+	5	2	2	3	2	5	1
Hantzschia amphioxys (Ehr.) Grun.	+	3	2	2	2	3	7	4
Melosira varians Agardh	+	4	2	3	3	3	5	2
Meridion curculare (Grev.) Agardh	+	4	2	2	2	2	7	1
Navicula cincta (Ehr.) Ralfs	+	4	2	2	3	3	5	4
Navicula cryptocephala Kütz.	+	3	2	2	3	3	7	2
Navicula rhynchocephala Kütz.	+	4	2	2	4	2	7	2
Navicula cf. *viridula* Kütz.	+	4	2	2	2	3	5	1
Nitzschia linearis W. Sm.	+	4	2	2	2	2	4	3
Nitzschia palea (Kütz.) W. Sm.	+	3	2	4	4	5	6	3
Nitzschia sigma (Kütz.) W. Sm.	+	4	4	2	3	3	5	2
Nitzschia sigmoidea (Nitzsch) W. Sm.	+	4	2	2	3	2	5	2
Pinnularia borealis Ehr.	+	3	2	2	1	2	2	4
Pinnularia maior (Kütz.) Rabenh.	+	3	2	2	2	2	4	2
Pinnularia viridis Ehr.	+	3	2	2	3	2	7	3
Pleurosigma salinarum Rabenh.	+	4	4	-	-	1	-	-
Rhopalodia gibba Kütz.	+	5	2	1	3	2	5	3
Surirella ovalis Bréb.	+	4	4	2	4	3	5	3
Tabellaria flocculosa (Roth.) Kütz.	+	2	1	1	1	2	3	3
Chrysophyceae								
Dinobryon divergens Imhof								
Dinobryon sociale Ehr.								
Erkenia subaequiciliata Skuja								
Synura echinulata Korš.								
Xanthophyceae								
Chlorobotrys simplex Pascher	+							
Gloeobotrys monochloron Ettl	+							
Myxochloris sphagnicola Pascher	+							
Ophiocytium parvulum A. Braun	+							
Ophiocytium sp.	+							
Tetraedriella sp.	+							

Table 2 – cont.

1	2	3	4	5	6	7	8	9
Chlorophyta/Chlorophyceae								
Ankistrodesmus fusiformis Corda	+							
Chlamydomonas globosa Snow	+							
Coelastrum astroideum De Notaris	+							
Crucigenia tetrapodia (Kirchner) W. & G.S. West	+							
Crucigeniella rectangularis (Näg.) Kom.	+							
Dictyosphaerium pulchellum Näg.	+							
Golenkinia radiata Chodat	+							
Koliella longiseta (Visch.) Hindák	+							
Microspora stagnorum Näg.	+							
Microthamnion kuetzingianum Kütz.	+							
Monoraphidium contortum (Thur.) Kom. Legn.	+							
Oocystis lacustris Chodat	+							
Pediastrum boryanum (Turp.) Menegh.	+							
Pediastrum duplex Meyen	+							
Pediastrum simplex Meyen	+							
Pediastrum tetras (Ehr.) Ralfs	+							
Scenedesmus ecornis (Ehrenb.) Chodat	+							
Scenedesmus quadricauda (Turp.) Bréb.	+							
Sphaerocystis planctonica (Korš.) Bourrelly	+							
Tetraedron caudatum (Corda) Hansg.	+							
Tetraedron minimum (A. Braun) Hansg.	+							
Tetrastrum triangulare (Chod.) Kom.	+							
Euglenophyta/Euglenophyceae								
Euglena acus Ehr.	+							
Euglena limnophila Lemm.	+							
Euglena mutabilis Schmitz	+							
Euglena pisciformis Klebs	+							
Phacus mirabilis Pochmann	+							
Trachelomonas hispida (Perty) Stein	+							
Trachelomonas oblonga Lemm.								
Trachelomonas volvocinopsis Swirenko	+							
Cyanophyta/Cyanophyceae								
Anabaena affinis Lemm.	+							
Anabaena lemmermanii Richter	+							
Anabaena planctonica Brunnth.	+							
Anabaena spiroides Klebahn	+							
Aphanocapsa incerta (Lemm.) Cronberg & Kom.	+							

Table 2 – cont.

1	2	3	4	5	6	7	8	9
Aphanocapsa planctonica (Smith) Kom. & Anagn.	+							
Chroococcus minutes (Kütz.) Näg.	+							
Chroococcus turgidus (Kütz.) Näg.	+							
Merismopedia elegans Kütz.	+							
Merismopedia glauca (Ehr.) Kütz.	+							
Merismopedia punctata Meyen	+							
Microcystis aeruginosa (Kütz) Kütz.	+							
Microcystis flos-aquae (Witrr.) Kirch.	+							
Oscillatoria limosa Agardh	+							
Oscillatoria maior Vauch.	+							
Oscillatoria tenuis Agardh	+							
Phormidium autumnale Agardh	+							
Phormidium granulatum (Gardner) Anagn.	+							
Planktolyngbya limnetica (Lemm.) Kom.-Legn.	+							
Pseudanabaena limnetica (Lemm.) Kom.	+							
Woronichinia naegeliana (Unger) Elenkin	+							
Woronichinia sp.	+							

Explanation of symbols:
R – ph; 2 – acidophilous, 3 – circumneutral, 4 – alkaliphilous, 5 – alkalibiontic.
H – salinity; 1 – fresh, 2 – fresh brackish, 3 – brackish fresh, 4 – brackish.
N – nitrogen uptake metabolism; 1 – nitrogen – autotrophic taxa, tolerating very small concentrations of organically bound nitrogen, 2 – nitrogen – autotrophic taxa, tolerating elevated concentrations of organically bound nitrogen, 3 – facultatively nitrogen – heterotrophic taxa, 4 – obligately nitrogen – heterotrophic taxa.
O – oxygen requirements; 1 – continuously high, 2 – fairly high, 3 – moderate, 4 – low.
S – saprobity; 1 – oligosaprobous, 2 – ß-mesosaprobous, 3 – ά-mesosaprobous, 4 – ά-meso-/polysaprobous, 5 – polysaprobous.
T – trophic state; 2 – oligo-mesotraphentic, 3 – mesotraphentic, 4 – meso-eutraphentic, 5 – eutraphentic, 6 – hypereutraphentic, 7 – oligo- to eutraphentic.
M – moisture; 1 – never or very rarely, 2 – mainly occurring in water bodies, sometimes on wet places, 3 – mainly occurring in water bodies, also rather regularly on wet and moist places, 4 – mainly occurring on wet and moist temporarily dry places.

had the biggest habitat diversity, especially ruderal ones (*Artemisietea vulgaris*, *Sisymbrietalia*), recorded on paths, in cracking of asphalt, in littered places, on rock debris and in other places, which are conducive to develop such small plant patches. The following species were dominating: *Arctium lappa*, *A. tomentosum*, *Artemisia absinthium*, *A. vulgaris*, *Berteroa incana*, *Cichorium intybus*, *Conyza canadensis*, *Lactuca serriola*, *Lepidium ruderale*, *Reseda lutea* and others. The rhizomous species characteristic to *Agropyretea intermedio-repentis* class, mainly: *Convolvulus arvensis*, *Elymus hispidus*, *Elymus repens*, *Equisetum arvense* were very important in overgrowing of bare cliffs around the "Szmaragdowe Lake" and unstable substratum, which was formed during exploitation. Quite small, but stable and quick spreading group of plants were species growing in rocks – *Asplenietea rupestria*, with characteristic taxa: *Asplenium ruta-muraria*, *A. trichomanes* and *Cystopteris fragilis*. After the percentage analyses of vascular plants' participation in listed phytocoenoses, it could be noticed, that in relation to ecological aspects, the domination of plants, which required sunny and warm habitats is very distinct. The diversity of flora, in case of the "Szmaragdowe Lake", mainly results from trophic types, humidity and granulometric structure of substratum. The remaining ecological indicators emphasize the influence of geological base, as well as climatic conditions (especially the access to sunlight from moderate to full). According to Zarzycki et al. 2002, taking into consideration, the trophic conditions the smallest percentage among the studied vascular plans (9%) are oligotrophic species, especially: *Allyssum alyssoides*, *Artemisia campestris*, *Asperula cynanchica*, *Asplenium ruta-muraria*, *Centaurea stoebe*, *Cerastium arvense*, *Dianthus carthusianorum*, *Festuca ovina*, *Jovibarba sobolifera*, *Sedum acre*, *Sedum reflexum*, *Seseli annuum*, *Veronica spicata*, which belong to xerothermic and rocky grassland patches. Mesotrophic species (28%) grow on ruderal and semi-natural,

moderately fertile habitats. This group is represented by: *Acinos arvensis*, *Artemisia absinthium*, *Asplenium trichomanes*, *Berteroa incana*, *Calamagrostis epigejos*, *Callitriche cophocarpa*, *Campanula glomerata*, *Cardaminopsis arenosa*, *Centaurea scabiosa*, *Cichorium intybus*, *Convolvulus arvensis*, *Cystopteris fragilis*, *Epilobium palustre*, *Picris hieracioides*, *Potentilla supina*, *Silene inflata*. Eutrophic plants, which constitute 32%, were recorded in places most often visited by humans and their pet animals, as well as in near-water zone of the reservoir.

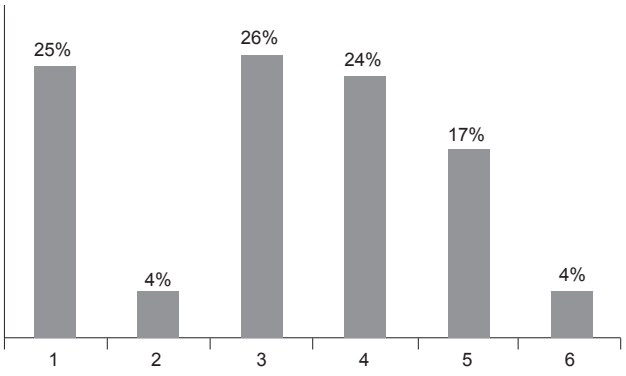

Fig. 3. Share of phytosociological units in the vascular flora of "Szmaragdowe Lake": 1 – synanthropic, 2 – forest brush, 3 – meadow, 4 – xerothermic grass, 5 – water marshes, 6 – others

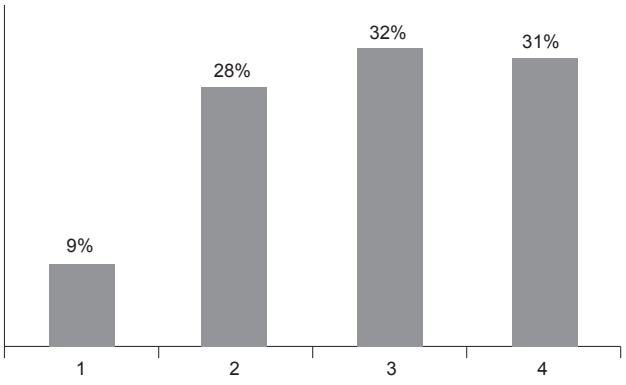

Fig. 4. Share of light value in the vascular flora of "Szmaragdowe Lake": 1 – oligophic, 2 – mezzophic, 3 – eutrophic, 4 – others

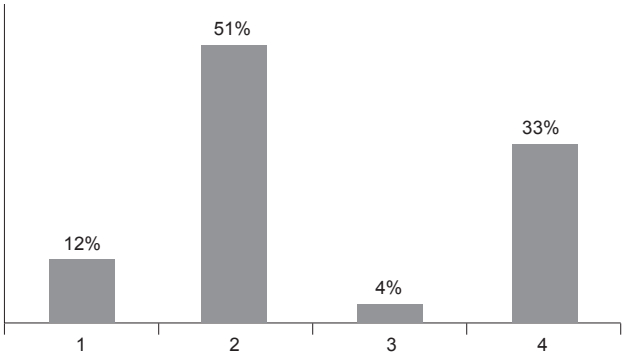

Fig. 5. Share of soil moisture value in the vascular flora of "Szmaragdowe Lake": 1 – dry, 2 – mesophyte, hygrophyte, 3 – hydrophyte, 4 – others

The dominant species were: *Alisma plantago-aquatica*, *Alopecurus pratensis*, *Arctium lappa* and *A. tomentosum*, *Bidens tripartita*, *Chenopodium glaucum*, *Elodea canadensis*, *Eupatorium cannabinum*, *Poa annua*, *Ranunculus acris*, *R. repens* and others (Figs 3-5).

The unstable substratum were the hardest places for plants to colonize, and that contained rock debris, gravel, sand and cracks, formed during exploitations. In those places the following species were noticed: *Allium montanum*, *Artemisia absinthium*, *Asperula cynanchica*, *Asplenium ruta-muraria* and *A. trichomanes*, *Berteroa incana*, *Cystopteris fragilis*, *Sedum acre* (12% of study flora). Very numerous group (51%) were the taxa, which were adapted to live on sandy-dusty soil; these were: *Alisma plantago-aquatica*, *Arctium lappa* and *A. tomentosum*, *Arrhenatherum elatius*, *Artemisia vulgaris*, *Festuca pratensis*, *Fragaria vesca*, *Leontodon autumnalis*, *Mentha aquatica*, *Ranunculus acris*, *Salix fragilis*, *Salvia verticillata*.

The least numerous group (33%) was composed of species with a wide tolerance range concerning the indicator of granulometric structure of substratum. These were: *Cichorium intybus*, *Lactuca seriola*, *Lepidium ruderale*, as well as common xerophytes, such as: *Acinos arvensis*, *Agrimonia eupatoria*, *Campanula rapunculoides*, *Centaurea scabiosa*, *Coronilla varia*, *Dianthus carthusianorum*, *Origanum vulgare*, *Potentilla arenaria* and ruderal or meadow apophytes: *Campanula patula*, *Carum carvi*, *Chenopodium glaucum*, *Epilobium palustre*, *Equisetum arvense*, *Falcaria vulgaris*, *Plantago major*, *Poa compressa*, *Silene vulgaris* and others. Some plants with adaptable anatomical structure and appropriate physiology were biological indicators, showing the degree of soil moisture. However, *sclerophytes* and succulents, overgrowing the carbonic cliffs of the quarry, were noteworthy in the study area. The most dominant among them were: *Asplenium ruta-muraria*, *A. trichomanes*, *Cardaminopsis arenosa*, *Elymus hispidus*, *Jovibarba sobolifera*, cluster of *Potentilla arenaria*, *Sedum acre* and *S. reflexum*, *Seseli annuum*.

84 species of algae and 22 taxa of cyanobacteria were observed in the "Szmaragdowe Lake"; among them are representatives of 5 systematic groups. Bacillariophyceae (42 species), Chlorophyceae (26 species) and Cyanophyceae (22 taxa) were found in largest numbers. Others algae groups, such as: Euglenophyceae (7 species), Xanthophyceae (5 species) and Chrysophyceae (4 species) were represented in small numbers. The diatoms were dominant in the "Szmaragdowe Lake". The most frequently occurring were the following: *Nitzschia palea*, *Cymbella cuspidata*, *Anomoeoneis sphaerophora*, *Caloneis amphisbaena*, *Cymatopleura solea*, *Navicula rhynchocephala*. The most common species among Chlorophyceae were: *Pediastrum boryanum*, *P. duplex*, *Microthamnion kuetzingianum*, *Microspora stagnorum*. Most species were noticed in springtime and in early summer, whereas the least in November. During the field investigations it was observed, that from the plankton organisms the representatives of Volvocales appeared at the earliest, shortly after in April. The diatoms developed in the summer and the most numerous species were that from classes: Chrysophyceae, Chlorophyceae and Cyanophyceae, while in autumn the diatoms were

again in majority. The cyanobacteria represented 20.7% of all identified species, among them prevailing were: *Anabaena planctonica*, *Oscillatoria limosa*, *Phormidium autumnale* and others. *Microcystis aeruginosa* was found in summer 2009, in this study lake. It is a cosmopolitan species connected with epilimnion, present in the saline and warm waters (Bucka and Wilk-Woźniak 2007). However, no negative influence of this species on the other taxa of the lake was observed. The trophy status was determined for all diatoms. The idea of trophy indicators is connected with diversity of growth rapidity for different algae species in various water types. It is a result of different state of water trophy status (rich in nutrients – eutrophic, unproductive – oligotrophic and intermediate – mesotrophic). The eutrophic species were dominant in the lake (24 taxa, among the others: *Achnanthes minutissima*, *Cocconeis placentula*, *Cymbella affinis* and *Navicula cryptocephala*). 13 species reached a tolerant status (*Amphora ovalis*, *Cymbella cuspidata*, *Gyrosigma attenuatum*), whereas five species – halophilic (i.e. *Denticula tenuis*, *Fragilaria ulna*, *Nitzschia sigma*, *Pleurosigma salinarum*). The investigations revealed that the "Szmaragdowe Lake" belongs to the group of reservoirs with medium organic pollution, which are characteristic for ά- and ß-mesosaprobic zone and only periodically for *oligosaprobic* zone. More frequently species from Chlorophyceae and Cyanophyceae were observed and their dominance during algal bloom in summertime was also noticeable.

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