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MACROPHYTES OF LAKE CRNO JEZERO ON DURMITOR MOUNTAIN (MONTENEGRO)

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In the frame of complex hydrobiological researches on the territory of National Park Durmitor, performed in the period od 1978-1984, botanical investigation of macrophytes has been undertaken in order to establish floristical composition and distribution of plant species and their populations found to live in the lakes. This article contains investigation results related only to lake Crno Jezero.

In lake Crno Jezero (Black Lake) 18 macrophytic species are recorded, of which 11 are vascular plants, 1 belongs to moss and 6 to charophytes. Besides, species distribution and analysis of ecological conditions are also presented in the paper.

Key words: Freshwater plants, *Charophyta*, flora, distribution, Yugoslavia.

Ključne reči: Slatkovodne biljke, *Charophyta*, flora, distribucija, Jugoslavija.

INTRODUCTION

Mt Durmitor, named „Soa nebeska” (Pillar of the sky) by its inhabitants, inspires by splendid beauty of its dense forests, blooming pastures, deep canyons and crystal clear rivers, diverse paysages and numerous lakes. Ten lakes and plenty of smaller hydrographic objects make this mountain peculiar, what first have been noticed by Cvijić (1899) and, later on, confirmed by other researchers (Stanković, S., 1975, 1985, 1992; Bešić, Z., 1963). The lakes are situated at the altitude between 1409 and 1788 m above sea level and differ mutually by its aspect, largeness, hydrological characteristics and genesis (Stanković, S., 1975, 1992). This diversity of biotops resulted in diversity of plant world living there, with regard to flora and space distribution of species and their populations.

Among Mt Durmitor lakes, lake Crno Jezero (Black Lake) distinguishes from the others by its largeness, genesis, hydrographical characteristics as well as by its touristic and economic importance. In consideration to diverse life conditions existing in the lake, floristical diversity and distribution of macrophytes were supposed to be significantly different from the other biotops of Mt Durmitor. In attempt to analyse this phenomenon, the authors carried out comprehensive investigation during summers 1982 and 1983.

MATERIAL AND METHODS

Sampling for floristical analysis and examination of space distribution is performed by transverse profiles and transects methods, using hook- and rake-type devices constructed by the authors and described in previously published papers (Blaženčić, J. & Blaženčić, Ž., 1991).

Charophytes determination is achieved according to Corillion, R., 1957, 1975, Gollerbah, M.M. & Krasavina, L.K., 1983 and by consulting Monograph and Iconograph by Wood, R.D. & Imahori, K., 1964, 1965. Vascular plants are defined using keys from Flora SR Srbije 1-8 (Josifović, M., 1970-1977), Flora SSSR 1 (Komarov i Il'in, 1934), Illustrierte Flora von Mittel-Europa (Hegi, D.G., 1965).

Bathymetric chart of lake Crno Jezero is taken over from Stanković (1975).

RESULTS AND DISCUSSION

Principal characteristics of biotop. Lake Crno Jezero lies near by village Žabljak, on Mt Durmitor, at the altitude of 1418 m above sea level. The lake's water level varies seasonally to a great extent, from 8 to 10 metres. The lake basin is divided in larger part, trending NE and named Big Lake, and smaller part towards SW, named Little Lake (Fig. 1).

Big Lake's littoral is almost entirely slightly sloped up to the bottom what is very favourable for macrophytic vegetation development. On the contrary, Little Lake's littoral along lakeshore is steep and rocky. Anyway, lake Crno Jezero lies on the limestone bedrock, with maximal depth of 24.5 m in Big Lake and 49.1 m in Little Lake.

Very transparent water and low organic production make this lake belong to oligotrophic and alpine-type. According to Purić (1983) the lake's water appears to be calcium-bicarbonate-type of freshwaters, with slightly alkaline reaction and pH-va-

lues range between 7.7 and 8.06. Water temperature fluctuates from 2.3°C in December, to 18°C in summer months. Being characterized by high oxygen content, low BOD₅ - values, absence of ammonium and nitrate ionic species, lake Crno Jezero seems to have a clean water.

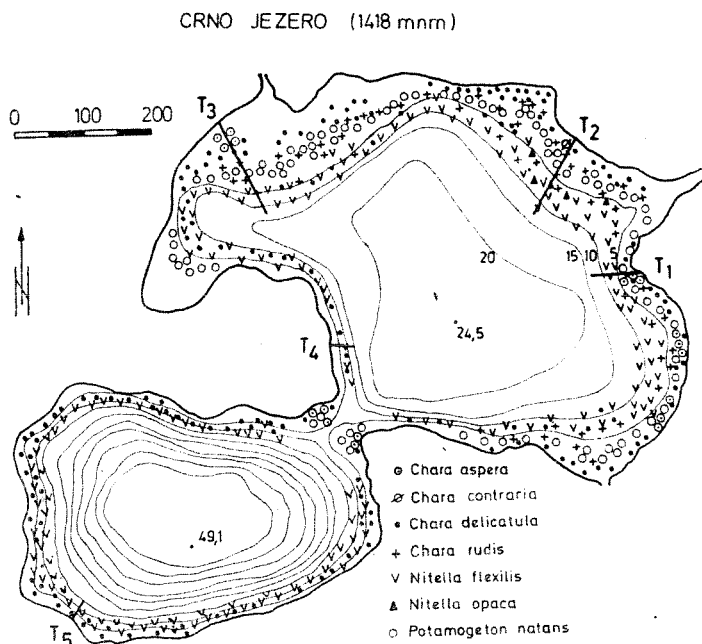


Fig. 1. - Distribution of dominant species in lake Crno Jezero

Floristical composition and macrophytes distribution in lake Crno Jezero. By floristical analysis of samples collected in the lake have been evidenced 18 species of which 6 species of algae belonging to division of *Charophyta*, 11 species of vascular plants and 1 species of moss.

According to available literature data, species recorded by the authors to live in lake Crno Jezero have not been evidenced so far. Most frequently mentioned genera are *Chara*, *Potamogeton*, *Myriophyllum* and *Ranunculus*. (Ivanović et al., 1968; Petković, Sm. & Petković, St., 1972; Petković, Sm., 1981). Rohlena (1942) reported *Nuphar luteum* L., *Potamogeton mucronatus* Schrad., *P. pectinatus* L., which have not been found by the authors to grow in the lake. Mentioned data point out to the fact that macrophytic flora in lake Crno Jezero has not been well known

as well as that some species have been disappeared with time from this locality. Only two species (*P. filiformis* and *P. natans*) from floristic list, established on the base of the author's investigation results, have been known in the lake's flora before. All others are new for the lake's flora, even for Mt Durmitor's flora, while *Nitella flexilis* is new species for the flora of Montenegro (Blaženčić, J., Blaženčić, Ž., Cvijan, M., 1991).

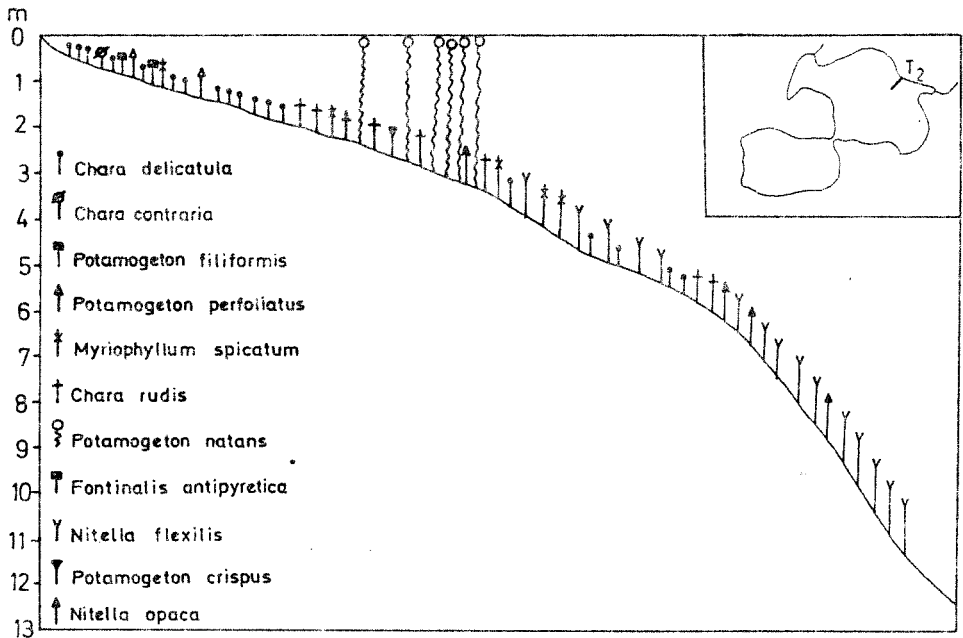


Fig. 2. – Distribution of aquatic plants along transect T2

In shallow water of the Big Lake's littoral, up to 2 m of depth, in detritus and shallow mud, between rocks, populaitons of *Chara aspera* Deth. ex Willd., *Chara contraria* A. Br. and *Chara delicatula* Ag. occur mosaically dispersed, making pure populations or mixed populations associated with *Chara rudis* A.Br., *Potamogeton pusillus* L., *P. filiformis* Pers., *P. perfoliatus* L., *P. natans* L. and *Ranunculus paucistamineus* Tsch. (Figs 1, 2, 3, 4).

Almost around the entire Big Lake (Northeastern part of lake Crno Jezero), at the depths between 2 and 4 m, extends the zone of floating *Potamogeton natans*. Before and behind and partly inside this zone, groupings of *Chara rudis* and *Ch. delicatula* are recorded (Figs 1, 2, 3, 4).

Mixed populations, developed between 2 and 6 m of the depths, beside mentioned species, include also *Myriophyllum spicatum* L., *P. perfoliatus*, *P. crispus* L. and *Nitella flexilis* Ag.

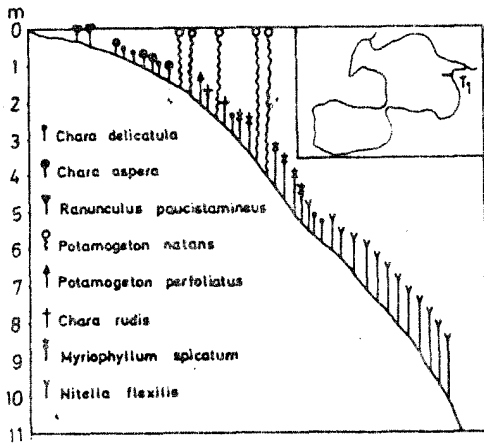


Fig. 3. – Distribution of aquatic plants along transect T₁

Further vegetation zone in Big Lake lies at depth of 6 to 10 m, building high and dense populations of *Nitella flexilis* and *N. opaca* Ag. (Figs 1, 2, 3, 4). In adjacent parts of this zone, toward the previous zone, occur *Nitella opaca* associated with *Ch. rudis* and *Myriophyllum spicatum*, and *Nitella flexilis* in association with *Ch. rudis*, *Ch. delicatula*, *P. natans*, *P. perfoliatus* and *Miyriophyllum spicatum*. Deeper of 6 m, only populations of *N. flexilis* and *N. opaca* are found to grow. The lower distribution limit of these species (11 m) is, at the same time, the lower distribution limit of macrophytic vegetation at all in Big Lake.

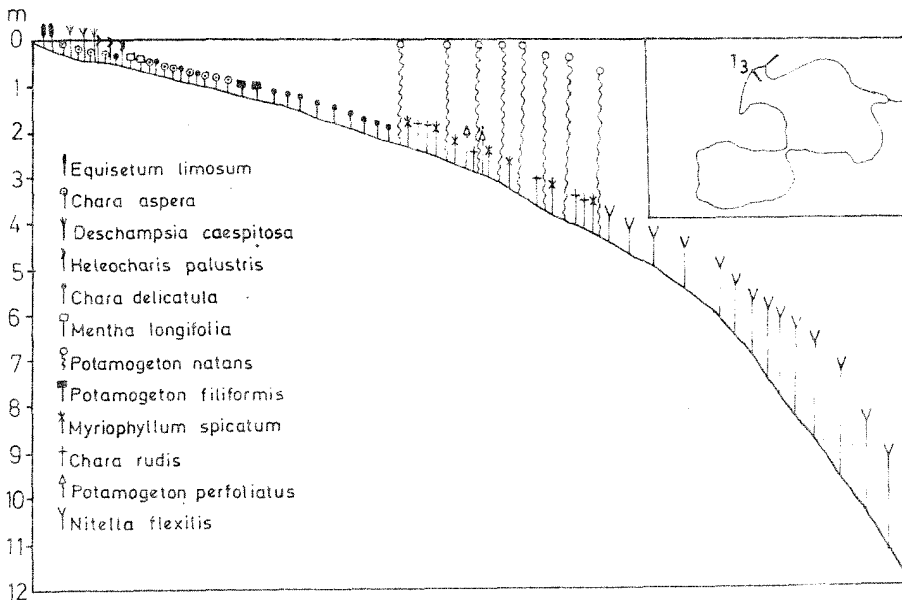


Fig. 4. – Distribution of aquatic plants along transect T₃

Macrophytic flora in Little Lake (Southwestern part of lake Crno Jezero) is represented with populations of *Chara delicatula* and *Nitella flexilis* (Figs 1, 6) which appear at the depths more than 4 m, caused by steep and rocky lake shorelines. Between 4 and 6 m, *Ch. delicatula* is more abundant than *Nitella flexilis*. With depth *Nitella flexilis* becomes more dominant, so that pure populations of this species appear somewhere at 5 m yet, but always at depths more than 8 m. Maximal depth of its extending recorded so far is 14.5 m. Identical floristic composition and similar vertical distribution exist also in Big Lake, in habitats with similar characteristics such as steep and rocky lake bottom (Figs 1, 4).

Northwestern part of the lake, where the Mlinški Potok enters in, is very interesting from floristical and phytocoenological viewpoint (Figs 1 - T₃, 4). This lakeshore is under the water in the case of high water level or covered with swampy meadows under the conditions of low water level.

In the investigation period the lake bottom was covered with dense carpet of *Chara aspera* in combination with following species: *Equisetum limosum* (L.) Roth., *Heleocharis palustris* R.Br., *Mentha longifolia* Huds., *Deschampsia coespitosa* Beauv., *Potamogeton filiformis* Pers. and *P. perfoliatus*.

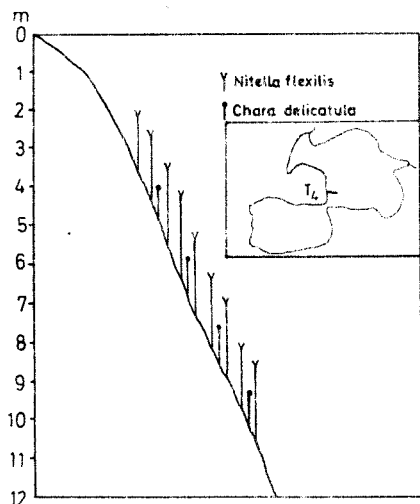


Fig. 5. -- Distribution of aquatic plants along transect T₄

Being subjected to significant seasonal water level oscillations, some parts of lakeshore are occasionally under the water or overgrown by swampy meadows after the drainage. The soil remains wet for some time, protected from fast drying up by vegetation that lives on after the water drains away. Aquatic plants withstand out of the water developing different adaptations to these conditions. Development of terrestrial forms of aquatic plants is the most frequent adaptation to dry conditions, found by the authors, during earlier investigations on the other places, in following species: *Nymphaea alba* L., *Nuphar luteum* Sm., *Nymphoides flava* Hill., *Potamogeton natans*, *P. gramineus* L., *Myriophyllum spicatum*, *M. verticillatum* L., species belong to genus *Trapa* L., *Hippuris vulgaris* L., *Ranunculus aquatilis* L. (Janković, M. & Blaženčić, J., 1968; Janković, M. et al., 1980).

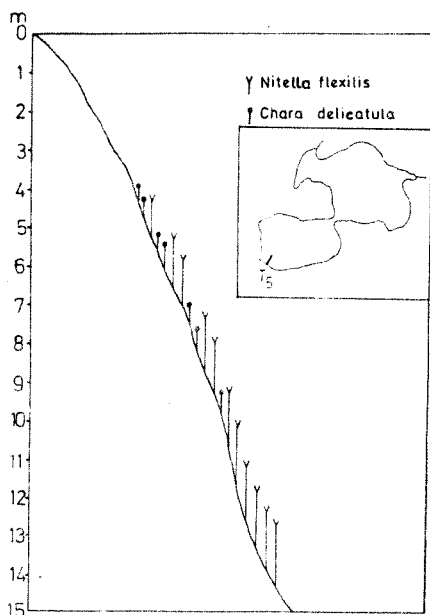


Fig. 6. – Distribution of aquatic plants along transect T₅

In the identical or similar habitats, charophytes *Chara aspera* and *Ch. vulgaris* L. develop occupying lower layer of marshy meadow vegetation. These species produce oospore thus surviving in wet mud disadvantageous life conditions. Oospores are highly resistant, staying viable during the winter period. Some charophytes produce bulbils in attempt to adapt themselves to unfavourable life conditions, like *Chara aspera* and *Ch. delicatula* in lake Crno Jezero. In re-established and suitable life conditions, charophytes grow vegetatively, most rapidly by developing branches, slowly from bulbils and quite slowly from spores.

CONCLUSION

Botanical investigation including analysis of floristical composition and space distribution of macrophytic vegetation in lake Crno Jezero on Mt Durmitor (Montenegro) is performed during summers 1982 and 1983.

Lake Crno Jezero (Black Lake) is situated at the altitude of 1418 m above sea level, on the limestone bedrock.

The water enters into the lake from permanent tributary and sublacustrine springs, and leaves the lake through periodical outlet, renewing the water mass, i.e. providing water flow through the lake basin. Great transparency (15 m) and low organic production include this lake in deep (24.5 m in Big Lake and 49.1 m in Little Lake) and oligotrophic, alpine-type of the lakes.

The lake water is calcium-bicarbonate-type with slightly alkaline reaction (pH 7.7-8.06).

Floristical analysis of samples collected along the transects shows the presence of 18 macrophytic species, of which 6 species of algae belonging to division of *Charophyta*, 11 species of vascular plants and 1 species of moss. Following species are recorded: *Chara aspera*, *Ch. contraria*, *Ch. delicatula*, *Ch. rudis*, *Nitella opaca*, *N. flexilis*, *Ranunculus paucistamineus*, *Heleocharis palustris*, *Equisetum limosum*, *Potamogeton natans*, *P. pusillus*, *P. perfoliatus*, *P. filiformis*, *P. crispus*, *Myriophyllum spicatum*. In some places along shoreline (Fig. 4), covered with dense populations of *Chara aspera*, marshy meadow's species *Mentha longifolia* and *Deschampsia coespitosa* are also found. Moss species *Fontinalis antipiretica* appears in few places in the lake. Only two among species mentioned above, have been accounted in flora of the lake before (*Potamogeton natans* and *P. filiformis*). Some species like *Nuphar luteum*, *P. pectinatus* and *P. mucronatus*, recorded by Rohlena (1942), have not been found during the author's investigations, on the basis of what could be concluded that they disappeared in the mean time.

Emergent plant zone does not exist caused by significant fluctuation of lake water level, between 8 and 10 m annually.

Floating plants represented by species *Potamogeton natans* develop only in the part of lake named Big Lake, at the depth of 2 to 4 m.

Submersed plants zone extends from coastal region up to the depth of 11 m in Big Lake or up to 14.5 m in Little Lake (Fig. 1) and is build of charophytes, which grow at all depths up to lower limit of macrophytes distribution, and vascular plants, which grow up to 5-6 m of depth (Figs 1-6).

In the lake shallows, up to 2 m, on shallow mud or detritus, in the zone of significant daily and seasonal fluctuation of ecological conditions, low tufts of charophytes develop scarcely (*Ch. contraria*, *Ch. delicatula*) or in a form of low carpet (*Ch. aspera*). With depth, number of species that participate in macrophytes vegetation decreases, plant carpet becomes more compact and individual plants more elongated. In the zone between 2 and 6 m are found *P. natans*, *P. perfoliatus*, *M. spicatum*, *Ch. rudis* and others.

Particular zone and lower limit of macrophytes distribution in lake Crno Jezero, is represented by dense, high (up to 1 m) submersed meadows built of species *Nitella opaca* and *Nitella flexilis* (Figs 1, 3, 4).

Vertical distribution of macrophytes, described in the paper, is characteristic of the lakes with clean and highly transparent water what represents another evidence which supports the state of Blindow (1992).

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Re z i m e

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Floristički sastav i distribuciju makrofita u Crnom jezeru na Durmitoru proučavali smo u leto 1982. i 1983.

Crno jezero nalazi se na nadmorskoj visini od 1418 metara. Leži na terenu krečnjačkog sastava. Ima stalnu pritoku, povremenu otoku i ponore na dnu pa pripada protočnom tipu jezera. Velika providnost vode (15 m) i niska organska produkcija uvršćuju Crno jezero u duboka (24.5 m Veliko i 49.1 m Malo jezero), oligotrofna jezera alpskog tipa. Voda Crnog jezera je kalcijum-bikarbonatna, slabo bazna reakcije (pH 7.7-8.06).

Florističkom analizom uzraka konstatovali smo prisustvo 18 vrsta makrofita, od kojih 6 vrsta pripada algama razdela Charophyta, 11 vrsta vaskularnim biljkama i jedna mahovinama. Konstatovane su sledeće vrste: *Chara aspera*, *Ch. contraria*, *Ch. delicatula*, *Ch. nudis*, *Nitella opaca*, *N. flexilis*, *Ranunculus paucistamineus*, *Heleocharis palustris*, *Equisetum limosum*, *Potamogeton natans*, *P. pusillus*, *P. perfoliatus*, *P. filiformis*, *P. crispus*, *Myriophyllum spicatum*. Na pojedinim mestima uz obalu (Sl. 4) gde dno prekriva gusta populacija *Ch. aspera*, zabeležene su i biljke močvarnih livada *Mentha longifolia* i *Deschampsia coespitosa*. Na više mesta u jezeru nalazi se i mahovina *Fontinalis antipiretica* L.

Od navedenih vrsta samo dve (*Potamogeton natans* i *P. filiformis*) su bile poznate za Crno jezero. Neke vrste kao npr. *Najas luteum*, *P. pectinatus* i *P. mucronatus*, koje je zabeležio R o h l e n a (1942) nisu konstatovane u toku naših istraživanja na osnovu čega bi se moglo zaključiti da su tokom vremena iščezle.

Zona emerznih biljaka u Crnom jezeru se ne formira što je pored ostalog posledica veoma izražene astatičnosti nivoa jezerske vode. Godišnja amplituda kolebanja iznosi 8-10 metara.

Flotantne biljke predstavljene su vrstom *P. natans* koja se razvija samo u delu jezera koje se naziva Veliko, na dubini od 2-4 metra.

Zona submerznih biljaka prostire se od oblaskog regiona do dubine od 11 metara u Velikom, odnosno do 14,5 metara u Malom jezeru (Fig. 1). Zonu submerznih biljaka grade harofite i vaskularne biljke. Harofite se nalaze na svim dubinama do donje granice rasprostranjenja makrofita a vaskularne biljke samo do dubine od 5-6 metara (Figs 1-6).

U plićim delovima jezera (do 2 m), na plitkom mulju ili detritisu između kamenja, u zoni izrazitog dnevno-noćnog i sezonskog kolebanja intenziteta ekoloških faktora, razvijaju se niske forme harofita u vidu razbacanih žbunova (*Ch. contraria*, *Ch. delicatula*) ili niskih tepiha (*Ch. aspera*).

Sa povećanjem dubine broj vrsta u vegetaciji makrofita se smanjuje, biljni pokrivač dna je sve kompaktniji, a individue sve izduženije. U zoni između 2 i 6 m dubine konstatovane su vrste *P. natans*, *P. perfoliatus*, *M. spicatum*, *Ch. rudis* i dr.

Posebnu zonu, donju granicu rasprostranjenja makrofita u Crnom jezeru, čine guste, visoke (do 1 m) podvodne livade koje grade vrste *Nitella opaca* i *Nitella flexilis* (Figs 1, 3, 4).

Opisana vertikalna distribucija makrofita karakteristična je za jezera sa čistom i visoko transparentnom vodom i još je jedan dokaz više u prilog mišljenju koje iznosi B l i n d o w (1992).

Ovim istraživanjima stvorena je baza podataka o florističkoj raznovrsnosti i prostornom rasporedu populacija konstatovanih vrsta. Na taj način stvorena je dobra osnova za dopunu florističke liste i praćenje dinamike promena u sastavu flore, a to, uz korišćenje drugih botaničkih i ekoloških kriterijuma može da bude dobar indikator stanja i promena u ekosistemu Crnog jezera.