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BIOCHEMICAL PARAMETERS OF MACROPHYTES IN LITTORAL RECREATION AREA AQUATORIES OF THE TILIGUL ESTUARY IN VERNAL PERIOD

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The macrophyte species composition and seasonal biomass in the spring period was investigated in representatives of green and red algae-macrophytes in each recreation area of the Tiligul estuary. The macro- and micro-element content in a homogenate of macrophytes was studied. Hydrochemical investigation of the littoral waters and surface and deep layers of the soil in the recreational areas of the Tiligul estuary was carried out. In red algae-macrophytes, a high correlation was noted between the following parameters: potassium and sodium; potassium and calcium; potassium and magnesium; sodium and chloride; calcium and chloride; and magnesium and chloride. A very high correlation between potassium and chloride was also noted. In green algae-macrophytes, there is a high correlation between indices such as: phosphorus and iron. We found that the biomass of algae-macrophytes across five recreational areas was highest in the «Atamanskaya Kosa» sector, both in the composition of macrophyte species and their biomass, while the lowest was observed in the «Tashinskoe» recreational area. We conducted complex measurements in the spring season, which allowed us to establish the ecological status of Tiligul estuary coastal waters.

Key words: macrophyte, ecolodical monitoring, littoral waters, macro– and micro– element, red and green algae, Tiligul estuary.

INTRODUCTION

Macrophytes play an important role in water ecology [12]. Firstly, they produce oxygen and provide oxygen sources for zoobenthos. Secondly, they provide a place for fish to spawn and for young fish to seek refuge from predators. Macrophytes growth mostly depends on day length, the amount and level of rains, and the concentration of macro- and micro-elements in waters including: phosphorus, magnesium, calcium, nitrogen concentration, organic and inorganic fertilizers, and pesticides [1]. Frequently some macrophyte species begin to grow vigorously and produce an abundant biomass of algae, while other species grow moderately are inhibited [7, 11]. The diversity of macrophyte species also plays a significant role as some species belong to either the green or red species of macrophytes [2]. Both of these species grow in the coastal waters along the Tiligul estuary. In different areas, different species of algae grow with different biomass amounts per square meter of littoral waters [10, 13]. We focused mainly on the five recreation areas of the Tiligul estuary. These include: Tashinskaya, Atamanskaya Kosa (Chieftain Spit), Anatolevskaya, Chervono-Ukrainka and Koblevo recreation areas. Villages are located around the recreation areas. The recreational areas encourage the development of buildings for recreation for the summer vacation season. The ecological condition of the littoral waters, therefore, is of significant importance [3]. The abundance of macrophyte species and their biomass per square meter of littoral waters aids in assessing the ecological status of coastal recreational territory across each area.

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The aim of this study was to determine biochemical parameters of macrophyte species in each recreation area of the Tiligul estuary in spring, and then for further to monitor changes in the aquatic macrophytes in the Tiligul estuary. To achieve these goals, we formulatied several tasks: to identify the macrophyte species growing in the littoral waters in each recreation area; to ascertain the hydrochemical parameters of waters and soils in each recreation area; and to determine such biochemical parameters as: enzyme activity, and the concentration of macro- and micro-elements in macrophyte homogenates. This research was carried out in the spring season, when macrophytes begin to grow following the winter period. In the littoral waters, benthic and deep soils we investigated the concentration of such macro- and micro-elements as: sodium, potassium, calcium, phosphorus, magnesium, iron, and chlorides. Mactophyte homogenate enzyme activity was investigated for such cellular enzymes as: lactate dehydrogenase, aspartate aminotransferase, amylase, alkaline phosphatase, and alanine aminotransferase. Detailed description of enzyme activity in macrophyte species will be presented in a separate article.

Small river macrophytes inhabit the aquatic environment, as in the deep water and in the coastal areas [5]. Macrophytes play a significant role in the functioning of aquatic ecosystems, as they derive a number of substances from the water and bottom sediment that are able to store macro- and micro-elements, and ions of heavy metals [4]. During their lifespan, submerged macrophytes absorb carbon dioxide and release oxygen, thereby providing oxygen and vital activity for ecosystem reservoirs that supports the heterotrophic organisms, oxidising dissolved and suspended organic matter. Macrophytes also participate in the decomposition of incoming to estuary fertilizers, herbicides, and other chemicals (including heavy metals, detergents), which ultimately leads to the neutralization of toxic substances in estuary coastal waters.

Macrophytes, like other groups of organisms, are constantly reacting to direct or indirect interaction with changing environmental factors. Aquatic plants, therefore, can be used as bioindicators of aquatic ecosystems, which allows visual inspection and assessment of the ecological status of the reservoir, which, in turn, makes it possible to determine the trophic properties of the waters. Monitoring of water bodies and watercourses using macrophyte indices and their communities should be carried out over several years. In order to confirm changes in the character of algae, it must be appropriated in parallel with hydrological and hydrochemical investigations.

For bioindicative assessment of the quality of waters, it is recommended to use an integrated method that includes: a full description of the floral aquatic plants the definition of indicators of the overall diversity of species richness; dominance; stability of the development of indicator species; and class of water purity using indicator significance of individual species of macrophytes.

MATERIAL AND METHODS

Vernal investigations were carried out throughout the stretch of the Tiligul estuary in five recreational areas: Tashinsky, Atamnskaya Kosa, Anatolevsky, Chervono-Ukrainka, Koblevo. The samples of macrophytes for investigation were taken from each recreational

area, and waters and soils were taken from 12 plots of the littoral aquatorie also from each recreational area of the Tiligul estuary.

Biochemical parameters of macrophytes were tested in the spring. Over this period of time, we investigated each of 5 littoral aquatories in the recreation areas of the Tiligul estuary, in addition to identifying parameters of macro- and micro- element concentration in macrophyte homogenates based on a principle of photometric analysis, carried out using a biochemical analyser Respons-920 (DiaSys Diagnostic Systems GmbH, Germany). All tests were conducted using reagents, and specific test kits for each tested parameter, incuding: calcium, phosphorus, magnesium, iron, and chloride. The kits were produced by the BioSystems Company (S.A. Costa Brava, Spain). Test kits for investigation of Chloride were produced by the Pliva Company, (Lachema Diagnostika, Brno, Czech Republic). Investigation of electrolyte, such as sodium and potassium, were carried out using ionometric determination by a biochemical analyser ILyte Na/K with ionselective block (produced by Instrumentation Laboratory Inc., Bedford, MA, USA). The most important cations for macrophytes investigation are: sodium, potassium, calcium, magnesium, and iron. The most important anions for investigation of macrophytes are: chloride and phosphorus. Macrophyte species collected from littoral aquatories of the Tiligul estuary. Algal tissue homogenized in the universal laboratory homogenizer, type MPW-309, laboratory tissue homogenizer cell disrupter (produced in Poland).

Statistical deviation and significance were evaluated by Student's *t*-test with *P*-value: $P < 0.1$; $P < 0.05$; $P < 0.01$. The Spearman rank correlation coefficient was also calculated for the tested parameters of macro- and micro-element content in the littoral green and red algae species isolated from 5 recreation areas. Each test was repeated three times to confirm the exact result. For both tested groups of green and red macrophytes, dispersion analysis (ANOVA) was also performed. The dispersion analysis (ANOVA), based on Fisher's test (unifactorial model), was applied. The *F*-criterion determined whether relevant samples belonged to one from a general aggregate, and then whether or not it was possible to pool them.

RESULTS AND DISCUSSION

In the vernal period, littoral waters are clear, without signs of foaming at the edges of coastal waters from the surface-active substances.

According to our investigation of coastal aquatic flora in the Tiligul estuary, conclusions can be reached concerning the processes of eutrophication. As a result of these processes, the estuary is formed from the excess of inorganic nutrients, through flushing them with coastal soils as a result of rainfall [15]. The compounds nitrogen, phosphorus, iron, potassium, and sulphur, are necessary for the normal development of aquatic plants as well as macrophytes. In the littoral aquatories, we noted rich grow of *Zostera noltei* Hornemann, 1832, which is not algae, but is an aquatic plant [6, 14, 16]. Their abundance on the estuary water surface is associated with cyanobacteria and increased growth of micro- organisms that consume all of the adjacent oxygen dissolved in the water, leading to the rotting seaweed that can be observed washed ashore. This manifests in the marked overgrowth of watercourse aquatic vegetation, and in the

presence of macrophytes indicating the ecological status of Tiligul estuary coastal waters, such as: *Cladophora laetevirens* (Dillwyn) Kützing, 1843. An abundant influx of nutrients comes about due to human activities; in particular with the presence of human recreational bases in the village Koblevo, in the Berezan district of the Nikolaev region. We indicated the following species of macrophytes *Cladophora laetevirens* (Dillwyn) Kützing, 1843, *Ceramium rubrum* (C. Agardh, 1811), *Ulva intestinalis* Linnaeus, 1753, *Ulva prolifera* O. F. Müller, 1778, and *Rhizoclonium tortuosum* (Dillwyn) Kützing, 1845.

The macrophyte biodiversity the waters of the littoral aquatories of the Tiligul estuary included the following species of green algae: *Bryopsis plumosa* (Hudson) C. Agardh, 1823; *Cladophora laetevirens* (Dillwin) Kützing, 1843; *Cladophora sericea* (Hudson) Kützing, 1843; *Rhizoclonium tortuosum* (Dillwyn) Kützing, 1845; *Ulva rigida* C. Agardh, 1823; *Ulva compressa* Linnaeus, 1753; *Ulva clathrata* (Roth) C. Agardh 1811; *Ulva plumosa* Hudson, 1778; *Ulva intestinalis* Linnaeus, 1753; and *Ulva flexuosa* Wulfen, 1803. Red algae species present included the following macrophyte species: *Polysiphonia violaceae* (Roth) Sprengel, 1827; *Polysiphonia nigrescens* (Hudson) Greville ex Harvey, 1833; *Polysiphonia sanguinea* (C. Agardh) Zanardini, 1840, *Polysiphonia elongata* (Hudson) Sprengel, 1827, and *Chondria capillaris* (Hudson) M. J. Wynne, 1991. Macrophytes are an important component of the aquatic ecosystem and broad changes in the abundance of individual species and community composition provide valuable information on how and why an ecosystem might be changing. Fig.1 shows the growth of the red macrophyte *Polysiphonia sanguinea* (C. Agardh) Zanardini, 1840, a young algae with branched sprigs. Fig. 2 shows *Polysiphonia nigrescens* (Hudson) Greville ex Harvey, collected from the «Koblevo» recreational area of the Tiligul estuary [8]. Fig. 3 shows the growth of green macrophyte *Ulva rigida* C. Agardh, 1823, to which are attached small clams [9]. Fig. 4 shows *Zostera noltei* Hornemann, 1832, the intertidal seagrass that grows in the littoral aquatories around the Tiligul estuary.

Concentration of macro- and micro-element parameters in macrophyte homogenates showed in tab. 1. To determine the concentrations of the macro- and micro- elements in macrophyte homogenate from different green and red species of algae it was needed to determine among them: potassium, sodium, calcium, phosphorus, magnesium, iron, and chloride.

The recreational area «Tashinsky» of the Tiligul estuary in coastal waters is characterised by poor growth of aquatic vegetation. The beach is strewn with shells of perished clams. The coastal waters on the Tashinsky recreational area form a bay of sorts. The coastal water is clear and transparent, with sandy benthic soils. The coastal zone from the edge of the water to the coastal slopes is rather broad, 25–30 metres in breadth, and strewn only with shells. The recreational area «Atamanskaya kosa» of the Tiligul estuary in coastal waters is characterised by abundant growth and biodiversity of macrophyte species, including red algae of the genus – *Polysiphonia* and green algae of the genera – *Ulva* and *Cladophora*. The coastal waters are clear and transparent, with stony benthic soils. The coastal zone from the edge of the water to the coastal slopes is rather narrow, around 2–3 metres in breath, and carpeted with gravel. The recreational area «Anatolevskaya» of the Tiligul estuary in coastal waters is characterised by moderate growth and biodiversity of macrophyte species. The coastal waters are turbid, not

Fig. 1. *Polysiphonia sanguinea* (C. Agardh) Zanardini, 1840

Fig. 2. *Polysiphonia nigrescens* (Hudson) Greville ex Harvey, 1833

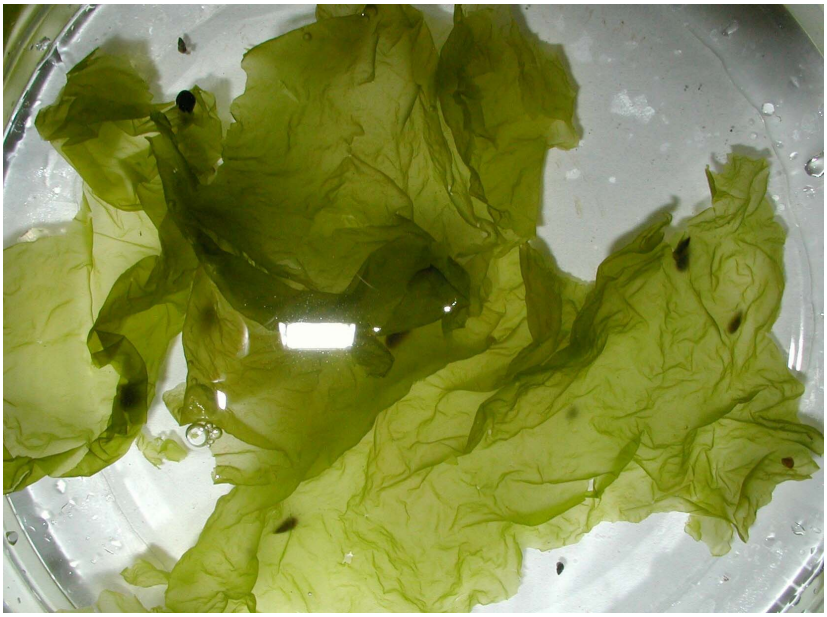

Fig. 3. *Ulva rigida* C. Agardh, 1823

Fig. 4. *Zostera noltei* Hornemann, 1832, the intertidal seagrass

transparent, with sandy benthic soils. The terrestrial coastal zone from the edge of the water to the coastal slopes is rather broad, of 15–20 metres in breadth, and is sandy. The recreational area «Chervono-Ukrainka» of the Tiligul estuary in coastal waters characterized by moderate growth and biodiversity of macrophyte species. The coastal waters are clear and transparent, with sandy benthic soils. The terrestrial coastal zone from the edge of the water to the coastal slopes is rather broad, of 10–15 metres in breadth, and is sandy. The recreational area «Koblevo» of the Tiligul estuary in coastal waters is characterized by rich growth and biodiversity of macrophyte species. The coastal waters are clear and transparent, with sandy benthic soils. The terrestrial coastal zone from the edge of the water to the coastal slopes is rather broad, of 10–15 metres in breadth, and is sandy. The pH of waters in the Tiligul estuary littoral aquatories were measured, and the result was the same, pH=7.0 (neutral), in each recreational area.

Table 1

Macro- and micro-element content in macrolpytes in different recreational areas of the Tiligul estuary

Macrophyte specie	**Potassium mmol/L**	**Sodium mmol/L**	**Calcium mmol/L**	**Phosphorus mmol/L**	**Magnesium mmol/L**	**Iron mmol/L**	**Chloride mmol/L**
1	2	3	4	5	6	7	8
Recreational area – Tashinsky							
Ulva clathrata	7.82±0.1	13.6±0.3	0.92±0.08	0.05±0.01	4.23±0.1	1.1±0.1	7.2±0.1
Recreational area – Atamanskaya Kosa (Chieftain Spit)							
Ceramium rubrum	1.22±0.03	14.1±0.2	0.64±0.03	0.09±0.01	1.23±0.07	2.3±0.2	3.8±0.1
Cladophora sericea	9.39±0.3	12.8±0.3	1.25±0.07	0.13±0.01	1.39±0.05	3.4±0.2	8.9±0.3
Ulva intestinalis	6.24±0.2	19.0±0.4	1.80±0.2	0.13±0.01	2.02±0.03	6.6±0.4	13.2±0.2
Ulva compressa	8.85±0.2	41.9±0.8	0.9±0.1	0.09±0.01	4.11±0.04	4.0±0.1	36.3±1.0
Polysiphonia nigrescens	1.15±0.1	15.9±0.6	0.87±0.06	0.10±0.01	1.32±0.03	6.2±0.2	5.4±0.3
Polysiphonia sanguinea	11.1±0.3	18.0±0.3	1.47±0.09	0.05±0.01	2.54±0.08	3.3±0.2	15.2±0.7
Recreational area – Anatolevskaya							
Cladophora laetevirens	4.04±0.1	13.8±1.7	0.50±0.1	0.02±0.006	3.41±0.1	5.9±0.4	5.7±0.2
Polysiphonia violaceae	0.53±0.02	11.1±0.1	0.94±0.06	0.01±0.001	0.72±0.02	7.8±0.5	3.0±0.2
Polysiphonia sanguinea	3.47±0.09	16.2±0.7	0.77±0.04	0.01±0.005	0.89±0.03	6.0±0.2	10.3±0.8
Ulva plumosa	7.18±0.1	21.5±1.6	1.14±0.1	0.15±0.03	1.47±0.1	19.1±0.4	79.0±3.4
Recreational area – Chervono–Ukrainka							
Polysiphonia violaceae	6.68±0.2	15.5±0.4	1.24±0.03	0.05±0.01	4.25±0.05	3.8±0.3	12.2±0.4

Ending of the table 1

1	2	3	4	5	6	7	8
Polysiphonia sanguinea	2.87±0.1	15.9±0.5	0.80±0.1	0.08±0.02	1.17±0.1	2.4±0.2	4.4±0.3
Ulva clathrata	5.62±0.1	19.1±0.6	1.18±0.02	0.83±0.03	2.63±0.07	23.3±1.3	18.9±0.5
Ulva intestinalis	7.46±0.1	13.4±0.8	1.19±0.01	0.04±0.01	0.73±0.04	12.2±0.7	11.6±0.4
Ulva compressa	1.33±0.03	10.8±1.2	0.77±0.09	0.02±0.003	1.27±0.02	7.1±0.3	3.1±0.2
Ulva rigida	2.66±0.1	11.0±0.3	1.19±0.04	0.05±0.01	1.26±0.02	6.8±0.2	3.9±0.2
Recreational area – Koblevo							
Polysiphonia violaceae	0.40±0.03	11.1±0.2	0.81±0.06	0.06±0.003	0.54±0.03	9.2±0.2	1.4±0.2
Polysiphonia sanguinea	1.6±0.2	13.8±0.5	0.44±0.03	0.04±0.002	1.56±0.09	9.1±0.2	3.1±0.3
Ulva rigida	0.26±0.04	9.3±0.3	0.78±0.05	0.03±0.004	0.35±0.03	3.6±0.3	2.9±0.2

Note to the table. Standard deviation between potassium and sodium, calcium and phosphorus, and sodium and chloride was calculated; statistical significance of difference was evaluated using Student's *t*-test; *P*-value: $P \leq 0.1$; $P \leq 0.05$; $P \leq 0.01$. *Ulva intestinalis* – this name is of an entity that is currently accepted taxonomically. *Enteromorpha intestinalis* – name is of an entity that is formerly used taxonomically. *Ulva intestinalis* is a green alga in the phylum Chlorophyta, of the genus *Ulva* (sea lettuce), also known by the common names gutweed and grass kelp. Until they were reclassified by genetic work completed in the early 2000s, the tubular members of the genus *Ulva* were in the genus *Enteromorpha*.

Macrophytes are also becoming increasingly valued as a means of indirectly monitoring water quality as, for instance, eutrophication can produce a progressive change in species composition and a loss of species diversity. Vernal biomass of macrophyte species is distributed in recreational areas as follows showed in tab. 2. The lowest macrophyte biomass was observed in the recreational area «Tashinsky». Moderate macrophyte biomass was present in the recreational areas «Anatolevskaya» and «Koblevo». The richest macrophyte biomass was seen in the recreational areas «Atamanskaya Kosa» and «Chervono-Ukrainka», they had a greater diversity of macrophytes in comparison with the other recreational areas.

Table 2

The algal biomass in spring in different recreational areas of the Tiligul estuary

Macrophyte species, in 1 m^2 of coastal waters	**Tashinsky** recreation area (g/m^2)	**Atamanskaya Kosa** recreation area (g/m^2)	**Anatolevskaya** recreation area (g/m^2)	**Chervono-Ukrainka** recreation area (g/m^2)	**Koblevo** recreation area (g/m^2)
1	2	3	4	5	6
Green algae species					
Briopsis plumosa	-	18.2±0.9	-	12.7±0.4	-
Cladophora laetevirens	-	-	12.4±0.8	-	14.8±1.0

Ending of the table 2

1	2	3	4	5	6
Cladophora sericea	-	68.2±2.2	8.3±0.2	-	-
Rhyzoclonium tortuosum	-	5.7±0.4	-	9.4±0.3	10.4±0.3
Ulva clathrata	-	–	-	23.8±0.9	16.3±2.1
Ulva compressa	16±0.7	20.6±1.1	-	28.4±2.8	-
Ulva intestinalis	-	27.4±0.9	-	24.6±1.2	-
Ulva plumosa	-	–	19.5±0.9	6.4±0.3	8.3±0.2
Ulva rigida	-	27.9±1.2	-	35.9±1.3	50.1±0.8
Red algae species					
Ceramium rubrum	-	24.8±1.3	-	-	-
Chondria capillaries	-	7.4±0.8	-	-	7.2±0.3
Polysiphonia nigrescens	-	84.7±2.0	-	-	16.8±0.7
Polysiphonia sanguinea	-	54.3±1.2	13.8±0.6	48.5±0.5	38.6±2.2
Polysiphonia violaceae	-	-	16.3±0.5	52.8±2.3	56.3±0.7
Total amount of biomass	16	339.2	70.3	242.5	218.8

Note to the table. Standard deviation was calculated; statistical significance of difference was evaluated using Student's *t*-test; *P*-value: $P \leq 0.1$; $P \leq 0.05$; $P \leq 0.01$.

Dispersion analysis showed in tab. 3, that there is no correlation between green and red algae in macro- and micro-element parameters. On the contrary, there existed an antagonistic correlation between the investigated algal groups. A negative correlation existed between many red macrophyte parameters; mostly between potassium and iron; sodium and iron; calcium and iron; phosphorus and iron; and magnesium and iron. A negative correlation existed between calcium and magnesium in green macrophyte species.

Fisher's criterion varied and fluctuated considerably between green and red macrophyte species. In the green macrophyte group, between parameters of sodium and chloride Fisher's criterion equalled zero. The equivalent Fisher's criterion in the red macrophyte group was more than 20 times that of the green macrophyte groups.

Table 3

Dispersion analysis (ANOVA) represents vernal fluctuations of macro- and micro-element content in isolated species of green and red algae from the Tiligul estuary

Parameters of algae	**Green algae species**			**Red algae species**		
	F	***P***	***Rs***	***F***	***P***	***Rs***
1	2	3	4	5	6	7
Potassium / Sodium	15.38	0.0008	0.04	64.93	<0.0001	**0.73**
Potassium / Calcium	23.15	0.0001	0.37	3.89	0.066	**0.82**
Potassium / Phosphorus	33.83	<0.0001	0.13	7.21	0.016	−0.11

Ending of the table 3

1	2	3	4	5	6	7
Potassium / Magnesium	11.73	0.002	0.44	1.75	0.20	**0.71**
Potassium / Iron	1.63	0.21	0.06	2.46	0.13	−0.50
Potassium / Chloride	2.94	0.10	0.41	2.76	0.11	**0.93**
Sodium / Calcium	33.15	<0.0001	0.07	305.59	<0.0001	0.44
Sodium / Phosphorus	37.11	<0.0001	0.16	349.62	<0.0001	0.22
Sodium / Magnesium	28.45	<0.0001	0.56	225.12	<0.0001	0.48
Sodium / Iron	5.97	0.02	0.09	56.82	<0.0001	−0.65
Sodium / Chloride	0	1.0	0.55	20.57	0.0003	**0.78**
Calcium / Phosphorus	54.16	<0.0001	0.25	65.29	<0.0001	−0.08
Calcium / Magnesium	6.07	0.02	−0.74	3.02	0.10	0.61
Calcium / Iron	12.41	0.002	0.23	25.86	0.0001	−0.39
Calcium / Chloride	5.7	0.02	0.14	12.34	0.002	**0.78**
Phosphorus / Magnesium	22.53	0.0001	0.13	15.64	0.001	0.04
Phosphorus / Iron	15.69	0.0007	**0.74**	36.32	<0.0001	−0.42
Phosphorus / Choride	6.36	0.02	0.15	16.31	0.0009	−0.20
Magnesium / Iron	8.91	0.007	−0.18	16.13	0.0009	−0.42
Magnesium / Chloride	4.99	0.03	0.08	9.01	0.008	**0.70**

Note to the table. *F* – Fisher's criterion; *P* – standard deviation; *Rs* – Spearman rank correlation coefficient; $P > 0.05$ – this means that, on the parameters indicated by bold.

CONCLUSIONS

Nutrients dissolved organic nitrogen, and inorganic calcium, phosphorus and magnesium are important factors that influence the development and species composition of submerged macrophyte communities in estuarine ecosystems.

The interactions of these factors could select macrophyte species that are able to resist the shading from phytoplankton/epiphyton, making these species more dominant in natural salty water ecosystems.

We found a high correlation in the red macrophyte species between the followng parameters: potassium and sodium; potassium and magnesium; sodium and chloride; calcium and chloride; and magnesium and chloride. A very high correlation in red macrophyte was noted between potassium and chloride; and potassium and calcium.

We observed that, in green macrophyte species, there exists a high correlation between phosphorus and iron.

We compared all recreational areas of the Tiligul estuary and determined that the largest number of macrophyte species and the greatest biomass were present in the recreational area of «Atamanskaya Kosa». The smallest number of macrophyte species and the least biomass was observed in the recreational area of «Tashinsky».

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Байрактар В. М., Полукарова Л. А. Біохімічні показники макрофітів у прибережних акваторіях рекреаційних ділянок Тилігульського лиману у весняний період // Екосистеми, їх оптимізація та охорона. Сімферополь: ТНУ, 2013. Вип. 9. С. 231–241.

Досліджувався видовий склад макрофітів, сезонна біомаса у весняний період у представників зелених і червоних видів водоростей-макрофітів на кожний рекреаційний ділянці Тилігульського лиману. Досліджували макро- і мікроелементний склад гомогенатів макрофітів. Проводилися гідрохімічні дослідження складу вод, поверхневих і глибоких шарів грунту в рекреаційних ділянках Тилігульського лиману. У червоних водоростей-макрофітів, була відзначена висока кореляція між такими показниками як: калій і натрій, калій і кальцій, калій і магній, натрій і хлориди, кальцій і хлориди, магній і хлориди. Відзначена дуже висока кореляція між показниками калію і хлоридів. У зелених водоростей-макрофітів, відзначається висока кореляція тільки між показниками фосфору і заліза. Встановлено, що біомаса водоростей-макрофітів з п'яти рекреаційних ділянок була найбільшою в ділянці «Отаманської коси», як за видовим складом, так і за біомасою, а найменшою виявилося в рекреаційний ділянці «Ташинський». Проведений комплекс досліджень у весняний період дозволив встановити екологічний стан прибережних акваторій Тилігульського лиману.

Ключові слова: макрофіти, екологичний моніторинг, прибережні води, макро- і мікроэлементи, червони і зелени водорості, Тилігульський лиман.

Байрактар В. Н., Полукарова Л. А. Биохимические показатели макрофитов в прибрежных акваториях рекреационных участков Тилигульского лимана в весенний период // Экосистемы, их оптимизация и охрана. Симферополь: ТНУ, 2013. Вып. 9. С. 231–242.

Исследовался видовой состав макрофитов, сезонная биомасса в весенний период у представителей зеленых и красных видов водорослей-макрофитов на каждом рекреационном участке Тилигульского лимана. Исследовали макро- и микроэлементный состав гомогенатов макрофитов. Проводились гидрохимические исследования состава вод, поверхностных и глубоких слоев грунта в рекреационных участках Тилигульского лимана. У красных водорослей–макрофитов, была отмечена высокая корреляция между такими показателями как: калий и натрий, калий и кальций, калий и магний, натрий и хлориды, кальций и хлориды, магний и хлориды. Отмечена очень высокая корреляция между показателями калия и хлоридов. У зеленых водорослей-макрофитов, отмечается высокая корреляция только между показателями фосфора и железа. Установлено, что биомасса водорослей-макрофитов из пяти рекреационных участков была наибольшей в участке «Атаманской косы», как по видовому составу, так и по биомассе, а наименьшей оказалось в рекреационном участке «Ташинское». Проведенный комплекс исследований в весенний период позволил установить экологическое состояние прибрежных акваторий Тилигульского лимана.

Ключевые слова: макрофиты, экологический мониторинг, прибрежные воды, макро- и микроэлементы, красные и зеленые водосли, Тилигульский лиман.

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