Algae, cyanobacteria, and microscopic fungi complexes in the Rybachy Peninsula soils, Russia

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Abstract
The investigation of algal-mycological complexes in the Rybachy Peninsula soils was carried out. The different types of tundra soils (Al-Fe-humus podzols, podburs, dry-peaty, peats low moor, cryogenic, undeveloped soils) were researched. The soil samples were collected along the route from Bolshaya Volokovaya Bay, which is in the Barents Sea, to the west of the Cape Nemetskiy. The organic horizons of the tundra podzols and podburs on the Rybachy Peninsula are less acid in comparison with the continental tundra soils of the region. Number of microfungi in the Peninsula soils varied from 9 to 70 thousand colony-forming units per 1 g of soil (CFU/g). It was the least in the cryogenic soils. The fungal mycelium length was significant in all the soils with the exception of the undeveloped one – more than 1 thousand m in 1 g of soil. The biomass amounted to 1.7 mg/g of soil. The species diversity of the soil micromycetes complexes is represented by 12 species. The species *Penicillium decumbens* dominated by the abundance and frequency of occurrence in the podburs, dry-peaty soils, podzols and peats low moor soils. *P. raistrickii* and *P. glabrum* predominated in the undeveloped soils, while *Mortierella stylospora* prevailed in the cryogenic soils. 62 eukaryotic algae as well as 18 species of cyanobacteria were found in the soil samples from Peninsula. The cryogenic and undeveloped soils, as well as Al-Fe-humus podzols and podburs were characterized by low species diversity, predominantly of green algae of classes Chlorophyceae and Trebouxiophyceae. Cyanobacteria and diatoms were noted by their considerable diversity in the dry-peaty soils and peats low moor soils.

Key words: biodiversity, tundra, soil, fungi, algae, cyanobacteria

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Introduction

The area of plane tundra territories is approximately 3 percent of the total continental area (Chernov 1980). Although the arctic tundra environmental conditions are unfavourable for life, the abundance of microorganisms, their high potential for activity and metabolic response to changes in living conditions make them important indicators of the environment state. In Davon Island, Canada (Widden 1977) and the Point Barrow, Alaska (Bunnel et al. 1980), the most intensive study of the tundra soils microflora and its activity in the Western Hemisphere were carried out. As to the Eastern Hemisphere, the research was conducted on the permanent study areas of Stordalen, Sweden (Hayes et Rheinberg 1975), Hardangervidda, Norway (Clarholm et al. 1975), Kevo, Finland (Baker 1974, Collins et al. 1978), Taimyr Peninsula, Russia (Bab′eva et Azieva 1980). The analytical review of the tundra soils microflora of the above mentioned regions was carried out by Parinkina (1989). The total microorganisms biomass in the Arctic tundra varies from 2 to 20 g/m^2 (Parinkina 1989, Bunnel et al. 1980). The intensity of microbial mass new formation achieves 15-20 generations per year in the most tundra soils (Parinkina 1989).

The fungi are significantly important in the Arctic ecosystems functioning, performing the destruction of plant remains in the soils. The number of micromycetes in the Arctic ecosystems is rather low: up to 1 thousand CFU/g in the soils and subsoils of Spitsbergen archipelago (Kirtsideli 2010), up to 0.5 thousand CFU/g in the soils of the stony tundra of the Putorana Plateau and the Polar Urals. It is worth pointing out that the number increases up to 1.2 thousand CFU/g, when moss and lichen vegetation makes an appearance. The appearance of low bushes increases the number up to 6.7 thousand CFU/g (Kirtsideli 2001). Generally, taxonomic composition of the tundra soils microbiota does not considerably differ from that of the temperate zone soils. The representatives of such genus as *Penicillium, Trichoderma, Mortierella*, are among the predominate ones in the Arctic Region. One can often come across such fungi as *Phoma, Phialophora, Acremonium, Mucor, Paecilomyces* (Evdokimova et Mozgova 2001, Kirtsideli 2001, 2010, Flanagan et Scarborough 1974). However, there is a set of features marked mostly by sterile fungi mycelium forms in the tundra soils (Evdokimova 1992, Parinkina 1989, Holding 1981, Syzova et Panikov 1993). An additional point is, that the considerable part of the tundra fungi is characterized by psychrophilic properties (Flanagan et Scarborough 1974). There is lack of data on microfungi productivity and production in the tundra soils. It was estimated that the fungi biomass is reproduced 2-6 times per season in Alaska tundra (Alexander 1974).

The algae and cyanobacteria are considered to be the main coenosis-building and important autotrophic components in the soil tundra ecosystems. They take part in forming the soil organic substance and in the biogeneous elements circulation (Shtina et Gollerbakh 1976, Hoffmann 1989). The results of the algological research could find their reflection both in a number of foreign editions (Brown et al. 1980, Cameron et al. 1978, Oleksowicz et Luścińska 1992) and in the native scientists (Andreeva 2004, Gezen et al. 1994, Evdokimova et Mozgova 2001, Perminova 1990, Sdobnikova 1986). In total, the tundra is characterized by a significant algae species diversity. It should be noted, that the main algae mass is concentrated in the upper layer of the soil. Green and yellow-green algae prevail in the ecosystems with developed ground vegetation in comparison with cyanobacteria and diatom ones (Gezen et al. 1994). The algal flora with predominantly cyanobacteria species develops on the exposed soil areas without vegetation. In the period of active ground vegetation the surface of the exposed soils is occupied with algae, up to 38 mln cell/cm^2 with biomass up to 7 mg/cm^2.

The Rybachy Peninsula is situated in the North-west of the Barents Sea coast. In accordance with the vegetation classification, this region is referred to the subarctic tundra (Koroleva 2006). The ancient Paleozoic sediments, such as shales, quartzites, dolomites, sand-rocks, lime-stones prevail on the Peninsula (Richter 1936). Al-Fe-humus podzols (Albic Podzols) [1] of the Al-Fe-humus soils formation predominate in the soil landscape of the Kola Peninsula tundra zone (Pereverzev 2001) [2]. The independent type of Al-Fe-humus soils is formed under the conditions of insufficient inland drainage, where there is no podzolic horizon, podburs (Entic Podzol). The Peninsula subdued topography is known for its hydromorphic dry-peaty soils (Folic Histosol) and peats low moor soils (Sapric Histosol). With a lack of permanently frozen ground, the cryogenic processes are of local character. They are evident as certain patches of the frost heaving-hydromorphic soil and subsoil flows on the soil surface.

Studies of soil microbiota of the Rybachy Peninsula have been performed relatively long time ago and only locally (Evdokimova et Mozgova 2001). The goal of this study is to give the characteristics of algal-mycological complexes in the Rybachy Peninsula soils.

Material and Methods

The soil samples were collected in July, 2015 along the route from Bolshaya Volokovaya Bay, which is in the Barents Sea, to the west of the Cape Nemetskiy. During this time period, the atmospheric temperature ranged from +6.4 to + 7.9°C. The soil temperature in the organic horizon ranged from +6.1 to + 8.7°C.

Table 1 gives aspects of the experimental plots. The soil samples were collected aseptically with the aim to carry out microbiological analyses. Three replicates per sampling site were taken either from the soil organic horizon, or from the cryogenic soil layer 0.5 cm. Altogether, 33 samples were selected and analyzed.

To characterize chemical and physicochemical soil properties, we determined the total carbon contents according to Nikitin (1983) with colorimetric termination according to Orlov-Grindel’ (Orlov et Grindel’ 1967). Total nitrogen was determined according to Kjeldal (Kjeldahl 1883). We used trilonometry for exchanged Ca^{2+} and Mg^{2+} and potentiometric method for pH of water and salt suspensions (1 : 2.5). Hydrolytic acidity was identified by reference to Kappen [3]. The number of micromycetes was estimated using the plating method on the wort agar, *i.e.* the agar with lactic acid addition (4 ml per 1 l medium for microbistatic). The analysis of the biological fungi diversity was fulfilled on the basis of cultured material. Morphological characteristics were evaluated using an optical microscope Olympus CX 41 (Olympus, Japan) with the camera JenopticProgRes CT3 (Jenoptik GmbH, Germany). Species identification was conducted using classical identification keys (Raper et Thom 1968, Egorova 1986, Domsh et al. 2007, Seifert et al. 2011). The species names were specified in accordance with the replenished species lists in the data base «Species fungorum», *see* [4] in Other sources for reference.

Plot no.	Coordinates, absolute heights	Thickness of the O horizon, cm	Soil type	Characteristics of the plot
1	69° 49' 17" N 32° 01' 58" E 20 m a.s.l.	0-15(20)	Podbur	Sea coast. Shrub tundra with associations of *Empetrum hermaphroditum* Lange ex Hagerup and *Betula nana* L.
2	69° 49' 31" N 32° 02' 10" E 73 m a.s.l.	0-20	Podbur	Shrub tundra with associations of *Empetrum hermaphroditum* and *Betula nana*
3	69° 18' 53" N 32° 03' 13" E 73 m a.s.l.	0-20(25)	Dry-peaty soil	Hillside. Shrub tundra with associations of *Empetrum hermaphroditum* and *Betula nana* in conjunction with *Equisetum sylvaticum* L.
4	69° 48' 5" N 32° 03' 30" E 100 m a.s.l.	0-7	Al-Fe-humus podzol	Shrub tundra with associations of *Empetrum hermaphroditum* and *Betula nana*, very speckled due to the exit of bedrock
5	69° 48' 55" N 32° 03' 30" E 100 m a.s.l.	absent	Soil of the cryogenic spot	70 sm diameter cryogenic spot without vegetation. Differentiated soil profile is absent.
6	69° 46' 02" N 32° 06' 03" E 51 m a.s.l.	0-30 and >	Dry-peaty soil	Birch elfin woodland with shrub (*Empetrum hermaphroditum*)-grass (Poaceae spp., *Geranium sylvaticum* L., *Cornus suecica* L., *Empetrum hermaphroditum*, Polypodiopsida spp., *Melampyrum sylvaticum* L., *Cirsium heterophyllum* (L.) Hill) communities.
7	69° 46' 03" N 32° 06' 10" E 66 m a.s.l.	0-5	Podbur	Shrub (*Empetrum hermaphroditum*)-lichen tundra
8	69° 45' 59" N 32° 05' 18" E 0 m a.s.l.	absent	Undeveloped soil. Stony-gravelly substrate in the tidal zone	Coastal strip of *Atriplex nudicalis* Bogusl.
9	69° 44' 17" N 32° 10' 44" E 116 m a.s.l.	0-5	Al-Fe-humus podzol	Plain shrub (*Empetrum hermaphroditum*)-lichen tundra.
10	69° 44' 16" N 32° 11' 15" E 107 m a.s.l.	0-30 and >	Peats low moor soil	Marsh with shrub willow (*Salix herbacea* L.) and grass (Cyperaceaea spp.,) communities.
11	69° 44' 39" N 32° 05' 25" E 15 m a.s.l.	0-12	Dry-peaty soil	Plain shrub (*Empetrum hermaphroditum*)-green moss tundra in conjunction with *Rubus chamaemorus* L, *Pinguicula vulgaris* L., *Andromeda polifolia* L.

Table 1. Characteristics of the plots located in Rybachy Peninsula.

The fungi mycelium length and its biomass were determined with the direct methods of fluorescence microscopy using method described by Olsen (Olsen et Hovland 1985). Soil suspensions were stained with acridine orange and FITC (SIGMA, Japan) and further were sucked through Whatman® Nuclepore™ Track-Etched Membranes with pore size 0.8 µm (polycarbonate, black). With a square grid inserted in an ocular the number of hyphal intersections was counted and the hyphal length calculated. The fungal biomass was calculated using the equation given by Paul and Clark [5]:

$$B_f = \pi r^2 L e S_c \qquad \textit{Eqn. } 1$$

where B_f is fungal biomass, r is hyphal radius 1.5 µm (Evdokimova et Mozgova 1996), L is hyphal length (cm×g soil^{-1}), e is hyphal buoyant density 1.05 g cm^{-1} (Mirchink 1988), and S_c is dry-matter content 0.15.

Both the plating method of soil suspension on the agar medium, and the method of liquid medium cultivation 3N-BBM and Z8 were used to taxonomic investigate of algae and cyanobacteria according to Gaysina et al. (2008), and Kótai (1972). Species determination based on the morphological character using a classical identification keys (Andreeva 1998, Ettl et Gärtner 2014, Komárek et Anagnostidis 1998, 2005, Komárek 2013). To make more specific the algae species names the electronic database Algaebase [6] was used.

The software package Microsoft Excel 2013 was applied for statistical processing such as Standard Error of the Mean and Student's t-test. Algae and cyanobacteria communities were analyzed by means of a clustering program GRAPHS, which used the Sørensen-Chekanovsky coefficient, and average distance as the measures of similarity (Novakovskiy 2006).

Results and Discussion

Physicochemical features

The organic horizons of the Rybachy Peninsula tundra soils were found less acid than those from the mainland region tundra soils. It is caused by the sea proximity and alkaline cations brought from the sea (Table 2). Consequently, the undeveloped soil of the Barents Sea coast has the neutral reaction.

The difference between water and salt suspension pH in the organic horizons of the Al-Fe-humus soils and dry-peaty soil was more than one, which testifies to high exchange acidity. The number of exchange calcium and magnesium in these horizons varied from 17.4 to 68.0 meq/100g. The hydrolytic acidity, providing insight into the content of the absorbed hydrogen ions in the soil and the degree of soil saturation with bases, was high in the organic horizon due to the availability of the fulvic acids abundance (Odum 1975, Parinkina 1989). The soil of the cryogenic spot was typical by extremely low content of exchange bases due to the lack of humus in these soils and fine mineral particles which are responsible for physical and chemical saturation capacity of soils.

Soil type	pH		Exchange Ca^{2+}, Mg^{2+}	Hydrolytic acidity	CEC	Base saturation, %
	H_2O	KCl	meq/100 g			
Al-Fe-humus podzol	4.4-5.1 4.8±0.04	3.1-3.5 3.3±0.1	8.3-27.2 17.4±3.1	31.6-102.2 60.6±10.0	78.0	22.3
Podbur	4.5-5.2 4.8±0.07	2.9-3.5 3.3±0.07	29.4-39.2 33.1±1.1	73.8-96.6 86.2±2.5	119.3	27.7
Dry-peaty soil	4.8-5.7 5.4±0.05	3.4-4.4 4.0±0.1	23.0-59.8 41.0±4.6	40.9-88.9 68.0±6.2	109.0	37.6
Peats low moor soil	6.1-6.4 6.3 ±0.1	5.4-5.7 5.6±0.1	34.1-103.6 68.0±4.7	18.6-49.8 32.8 ±9.1	100.8	67.5
Soil of the cryogenic spot	5.1	4.4	2.5	1.2±0.2	3.7	67.6
Undeveloped soil	7.2	6.7	-	-	-	-

Table 2. Physicochemical properties of O horizons of Rybachy Peninsula soils.
Note: Here and below the dash means the determination was not conducted. The figures above and below the line show the range of values and the mean and its error, respectively.

Organic substance

The organic substance and nitrogen content in the soils of the Rybachy Peninsula are presented in Table 3. C/N ratio in the organic horizon of the Al-Fe-humus soils reached high values with maximum of 43-44. In the vegetation-free cryogenic soil lacking organic horizon, the content of the organic substance is likely to be considered high, in respect that there is absence of litter currently.

The content of the water-soluble humus in the Rybachy Peninsula soils is higher than in the mainland soils of the region. The concentration of water-soluble carbon in the organic horizons was up to 400mg/100g, accounting for more than 1% of the total organic substance content. The smallest amount of the water-soluble organic substance found in the cryogenic soil was 27mg/100g.

Soil type	C	N	C:N	C_{H_2O} mg/100g / % of C_{tot}
Al-Fe-humus podzol	12.75-49.50 31.51±5.45	0.05-1.39 0.72±0.20	43.8	390/1.23
Podbur	45.44-56.51 50.76±1.31	1.03-1.41 1.19±0.05	42.6	436/0.87
Dry-peaty soil	24.27-52.97 39.87 ±3.62	1.11-2.17 1.54 ±0.14	25.9	404/1.07
Peats low moor soil	7.41-32.80 19.80 ±7.34	1.21-1.44 1.33 ±0.07	14.9	388/1.96
Soil of the cryogenic spot	3.7	0.04	92.5	27/0.73

Table 3. The organic matter composition in studied tundra soils (% of absolutely dry soil).

Microfungi

Number of microfungi varied from 9 to 70 thousand CFU/g (Fig. 1). The smallest number of micromycetes was detected in the cryogenic soils. It is not surprising, as there is a lack of vegetation on these areas. The number of microfungi was comparably same in the podburs, podzols and dry-peaty soils and accounted for 50-70 thousand CFU/g of soil. These values can be found at the lower limits of the micromycetes amount in the background tundra soils in the Kola Peninsula (Korneykova 2015).

The fungal mycelium length and its biomass in the podzol were slightly below than in the podburs dry-peaty and peats low moor soils. However, it is significant in all these types of soils and amounts to 1 thousand m in 1 g of soil and more than 200 m in 1 cm^3 (*see* Table 4). The fungal biomass reached the amount up to 1.7mg/g of soil. The mycelium length in the undeveloped soil was lower by a factor of hundreds. It is clearly enough because heterotrophic fungi biota is highly demanding for nutrient source.

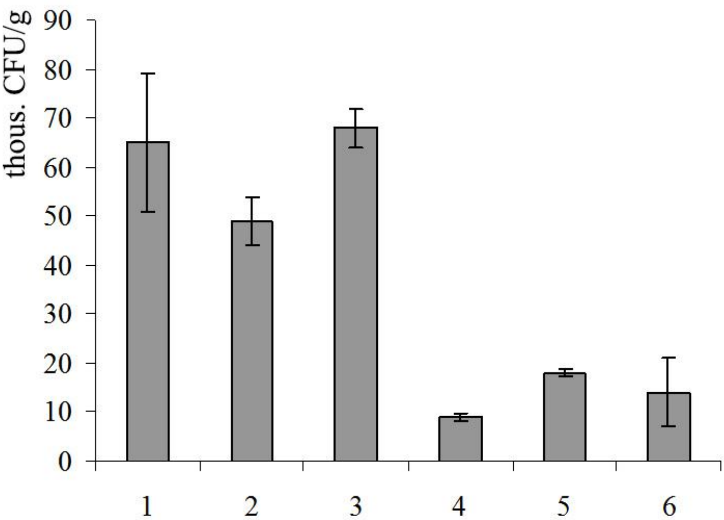

Fig. 1. Number of the microfungi in Rybachy Peninsula soils.
1 – Podbur, 2 – Dry-peaty soil, 3 – Al-Fe-humus podzol, 4 – Soil of the cryogenic spot, 5 – Undeveloped soil, 6 – Peats low moor soil.

Soil type	Length		Biomass		
	m/g	m/cm^3	mg/g	mg/cm^3	g/m^2
Al-Fe-humus podzol	1137±110	227	1.25	0.25	25.0
Podbur	1413±238	283	1.55	0.31	31.1
Dry-peaty soil	1538±334	308	1.69	0.34	33.8
Peats low moor soil	1482±230	296	1.63	0.33	32.6
Soil of the cryogenic spot	5.4±0.5	1.1	0.01	0.001	0.1

Table 4. Length and biomass of fungal mycelium in O horizons of Rybachy Peninsula soils (per unit of weight of absolutely dry soil).

Comparing the obtained readings according to the plating method and microscopic count, it was obvious that there was a substantial difference in the results for the peats low moor soil. In accordance with the plating method, the number can be compared with that one in the cryogenic and undeveloped soils. While in accordance with the method of microscopic count, the number comparable with the podburs, podzols and dry-peaty soils. To prove this suggestion, more detailed study of the fungi biomass structure (separate accounting of spores and mycelium, detecting of mycelium viability) is necessary.

Species diversity of the microfungi complexes on the Rybachy Peninsula was represented by 12 species which belong to 7 families, 6 orders, 5 classes and 2 divisions (*see* Table 5). The most micromycetes diversity was allocated in the podburs, dry-peaty soils and podzols (about 7-10 species). The least micromycetes diversity was found in the cryogenic, undeveloped and peats low moor soils (about 3-4 species).

The species *Penicillium decumbens* was dominant by the abundance and frequency of occurrence in the podburs, dry-peaty soils, podzols and peats low moor soils. The cryogenic and undeveloped soils were different from the other soils by their soil complexes micromycetes composition. *P. raistrickii* dominated by its spatial frequency of occurrence in the undeveloped soils. *P. glabrum* dominated by the abundance both in the undeveloped soils and in the podburs. *Mortierella stylospora* was prevalent by its abundance in the cryogenic soils, while *P. decumbens* dominated by its frequency of occurrence.

Algae and cyanobacteria

In total, 80 algae and cyanobacteria species referring to 5 divisions were found: Chlorophyta (31 species), Ochrophyta (25), Cryptophyta (1), Charophyta (5), Cyanobacteria (18). The soil series is in accordance with the growth of species diversity in them: cryogenic and undeveloped soils (including 6 species) – Al-Fe-humus podzols (13) – podburs (18) – dry-peaty soils (39) – peats low moor soils (53).

Cluster analyses of the floristic composition showed that cyanobacteria-algae coenosis of Al-Fe-humus podzols and podburs were mostly similar (Fig. 2). Altogether, 21 algal species have been discovered in the above-specified soils. According to the diversity species, green algae of Chlorophyceae and Trebouxiophyceae dominated. Such species as *Borodinellopsis* cf. *oleifera* Schwarz, *Coccomyxa* cf. *confluens* (Kützing) Fott., *Elliptochloris bilobata* Tschermak-Woess, *Pleurastrum* sp., *Parietochloris* sp., *Pseudococcomyxa simplex* (Mainx) Fott, *Stichococcus bacillaris* Nägeli were often found. *Eustigmatos magnus* (J. B. Petersen) D. J. Hibberd was the single representant of the Ochrophyta division. Yellow-green algae and diatoms were not found. Only *Aphanocapsa* sp. was met out of cyanobacteria.

Green algae (Chlorophyta) were the key microautotrophs also in the dry-peaty soils. Diversity of cyanobacteria, with 18% of total species richness, was higher in contrast to the soils, which were mention above. Diatoms (26% of total species number), mostly represented by the species of *Eunotia* and *Pinnularia* genera were discovered in the soils.

Genus	Soil type					
	Podbur	Dry-peaty soil	Al-Fe-humus podzol	Soil of the cryogenic spot	Undeveloped soil	Peats low Moor soil
Division *Zygomycota* Class *Incertae sedis* Order *Mortierellales* Family *Mortierellaceae*						
Mortierella stylospora Dixon-Stew.	0.3/22	0.8/33	0.4/17	45/33	-	6/100
Order *Mucorales* Family *Mucoraceae*						
Mucor plumbeus Bonord.	-	0.4/11	-	-	1.7/33	-
M. hiemalis Wehmer	0.1/11	0.1/11	-	-	0.5/33	0.8/33
Division *Ascomycota* Class *Eurotiomycetes* Order *Eurotiales* Family *Trichocomaceae*						
Penicillium decumbens Thom	37.2/100	71/100	49.2/100	27/100	-	91/100
P. glabrum	44/100	16/67	15.6/83	27/33	61//33	-
P. raistrickii Smith.	6.5/44	0.4/22	12.6/33	-	37/100	-
P. spinulosum Thom	0.1/11	9/22	0.7/17	-	-	-
P. nigricans K.M. Zaleski	0.6/11	-	-	-	-	-
Class *Sordariomycetes* Order *Hypocreales* Family *Hypocreacea*						
Trichoderma polysporum (Link.)	9.5/33	2/33	15.3/50	-	-	2.6/33
Family *Incertaesedis*						
Gliomastix roseogrisea (S.B. Saksena) Summerb.	-	-	0.4/33	-	-	-
Class *Dothideomycetes* Order *Dothideales* Family *Dothioraceae*						
Aureobasidium pullulans (De Bary) Arnaud	0.5/11	-	-	-	-	-
Class *Leotiomycetes* Order *Helotiales* Family *Sclerotiniaceae*						
Trichosporium macrosporum Kamyshko	0.1/11	-	-	-	-	-
Class *Incertae sedis* Order *Incertae sedis* Family *Incertae sedis*						
Sterilia mycelia	0.3/11	-	-	-	-	-

Table 5. Species diversity of the microfungi complexes in Rybachy Peninsula soils.

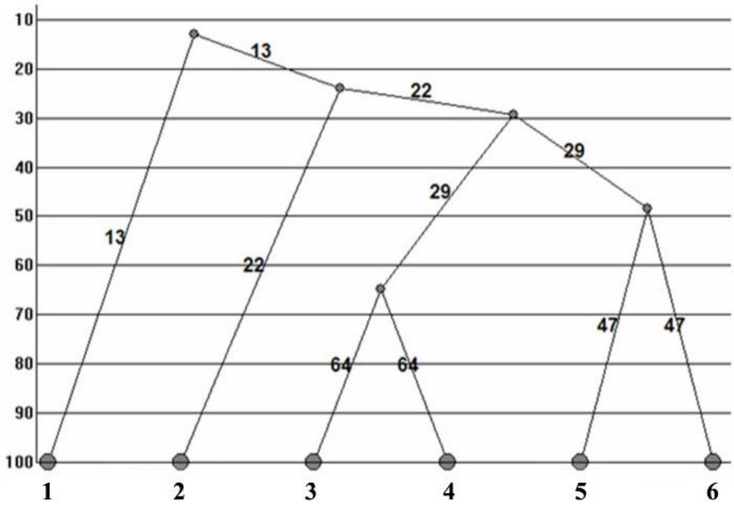

Fig. 2. Claster analyses of the floristic composition of cyanobacteria-algae coenosis in Rybachy Peninsula soils.
1 – Undeveloped soil, 2 – Soil of the cryogenics pot, 3 – Al-Fe-humus podzol, 4 – Podbur, 5 – Dry-peaty soil, 6 – Peats low moor soil.

The highest species abundance, accounting 53 species was found in the peats low moor soil. The flora richness is caused by the long-term overmoistening, organic substance accumulation, and reduction processes. The main three group representatives (green algae, diatoms, cyanobacteria) bring in the equal contribution into the total biodiversity (25, 28, 30 percent of the total species number, respectively). Aquatic and typical for highly wetted habitats taxa from Conjugatophyceae: *Cosmarium* cf. *impressulum* Elfving, *C. quadratum* Ralfs ex Ralfs, *Mougeotia* sp. were found in the peats low moor soil. Cyanobacteria *Microcoleus vaginatus* Gomont ex Gomont, *Geitlerinema* cf. *splendidum* (Greville ex Gomont) Anagnostidis, *Leptolyngbya* sp., *Pseudoanabaena* sp. were detected in all the samples of this soil type. Furthermore, the representatives of the genera *Aphanocapsa*, *Aphanothece*, *Chroococcus*, *Nostoc, Anabaena* were revealed as well. Among the diatoms, there were both fine species which were difficult to identify in the vital mixed cultures without special specimen preparation, and sufficiently large diatom representatives: *Hantzschia amphioxys* (Ehrenberg) Grunow, *Pinnularia* cf. *divergens* W. Smith, *P.* cf. *brebissonii* (Kützing) Rabenhorst, *P.* cf. *macilenta* Ehrenberg, *Rhopalodia gibberula* (Ehrenberg) Otto Müller, *Frustulia rhomboides* (Ehrenberg) De Toni. The yellow-green algae were found in the peats low moor soil as well: *Characiopsis* sp. and *Xanthonema* cf. *exile* (Klebs) P.C. Silva. The great species diversity of the main algae groups and the large diatom presence are characteristic features of the peats low moor soils algae flora (Shtina et al. 1998) which is consistent by our study.

Conclusions

The organic horizons of the tundra podzols and podburs on the Rybachy Peninsula are less acid in comparison with the continental tundra soils of the region. The amount of the exchanged calcium and magnesium varied from 17.4 to 68.0 meq/100g. The content of the water-soluble carbon amounted up to 400mg/100g constituting 1-2% of the total organic substance content. In such a case, its lowest quantity was registered in the cryogenic soil – 27mg/100g of soil.

The number of microfungi in the Peninsula soils varied from 9 to 70 thousand CFU/g. It was the least in the cryogenic soils. The fungal mycelium length was significant in all the soils with the exception of the undeveloped one-more than 1 thousand m in 1g of soil. The biomass amounted to 1.7mg/g of soil.

The species diversity of the soil micromycetes complexes is represented by 12 species. The cryogenic and undeveloped soils were distinguished by the species composition and micromycetes complex structure from the other Peninsula soils. The species *Penicillium decumbens* dominated by the abundance and frequency of occurrence in the podburs, dry-peaty soils, podzols and peats low moor soils. *P. raistrickii* and *P. glabrum* predominated in the undeveloped soils, while *Mortierella stylospora* prevailed in the cryogenic soils.

62 eukaryotic algae as well as 18 species of cyanobacteria were found in the soil samples from Peninsula. The soil series in conformity with the species diversity growth can be introduced as follows: the cryogenic and undeveloped soils – Al-Fe-humus podzols – podburs – dry-peaty soils – peats low moor soils. The cryogenic and undeveloped soils, as well as Al-Fe-humus podzols and podburs were characterized by low species diversity, predominantly of green algae of classes Chlorophyceae and Trebouxiophyceae. Cyanobacteria and diatoms showed considerably higher bio-diversity in the dry-peaty soils and peats low moor soils than in other soil types. Alongside with the green algae, they provide added value to the general biodiversity.

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