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Diversity of the Cyanoprokaryota of the area of settlement Pyramiden, West Spitsbergen Island, Spitsbergen archipelago

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Abstract: The diversity and ecological distribution of cyanoprokaryotes in the area of settlement Pyramiden of West Spitsbergen Island, Spitsbergen (Svalbard) archipelago, were studied during the summer seasons 2008 and 2013. A total of 73 taxa were observed in various habitats of investigated area. The highest number of species was found on wet seepages on the slopes (33 species), in slow tundra streams (26 species) and wet soils (21 species). *Nostoc commune* and *Calothrix parietina* dominate in most parts of the habitats.

INTRODUCTION

Cyanoprokaryota (Cyanophyta, Cyanobacteria) comprise prominent and essential autotrophic component of polar biota. They are intense producers of organic biomass during the polar summer season (Komárek et al., 2012). Cyanoprokaryota are widespread in all polar environments. They play a key role in Arctic ecosystems as diazotrophs.

Study of the cyanoprokaryotes of Spitsbergen archipelago began in the 19th century (Skulberg, 1996). There are numerous publications concerning the diversity of the freshwater and terrestrial cyanoprokaryota of Spitsbergen archipelago (Willen, 1980; Matuła, 1982; Plichta & Luścińska, 1988; Matuła & Swies, 1989; Perminova, 1990; Oleksowicz & Luścińska, 1992; Davydov, 2005, 2008, 2010, 2011, 2013; Kaštovská et al., 2005; Turicchia et al., 2005; Komárek et al., 2006, 2012; Matuła et al., 2007; Kim et al., 2008, 2011; Richter et al., 2009).

The present study adds new information on the freshwater and terrestrial cyanoprokaryota on the Spitsbergen archipelago. The data were collected during July–August 2008 and 2013.

MATERIAL AND METHODS

Study area

The investigated area is located in the central part of Spitsbergen, in the eastern part of the Dickson Land, on the western shore of Billefjorden. The relief of this part of Spitsbergen is sharply dissected and characterized by significant elevations. Area is surrounded by mountains which reach from 265 up to 935 m a.s.l. The investigated territory is situated within the field of rocks of the Paleozoic (541 to 252 million years ago).

The rocks of the Lower Carboniferous (358,9 to 298,9 million years ago) are widespread. They are presented by conglomerates, sandstones and limestones with local occurrence of coal. Also in the area there are Devonian (419.2 to 358.9 million years ago) rocks, composed of sandstone, siltstone, quartzitic sandstone and mudstone.

The hydrological system of the area is quite extensive. It is presented by the river Mimer and its tributaries, which occupy the central part of the valley. River supply is provided by the melting glaciers and to a lesser extent by precipitation. Flooding takes place in June and July, mean water is in August.

Soil profile is shallow and typical for the high Arctic. Soil cover is patterned; most part of soils has developed on topography that has been shaped by cryoplanation, on materials disturbed by sloping processes and erosion.

Climate of the area is determined by the influence of several ocean currents, one of them, branch of the Gulf Stream, is of particular importance. It is responsible for high air humidity and precipitation. July is the warmest month with average temperature +6.8° C (Petchurov, 1983; more in detail Láska et al., 2012).

Methods

Samples were collected during 25 July–3 August, 2008 and 1–10 August, 2013 in the area covering Mimerdalen, Tordalen valleys, Planteryggen, Reuterskiöldfjellet, Pyramiden, Svenbrehøgda mountain slopes (Fig. 1, Table 1). In total, 243 samples were collected. Least number samples were collected under the bird colonies (6) and in fast streams (5), and the maximum in the slow streams (26) and seepages (33). The species of cyanoprokaryota were identified, measured and photographed using the optical microscope AxioScope A1 (Zeiss©). The presence or absence of species on the samples were recorded; the abundance of species was not considered. For species identification, essential monographs were used (Geitler, 1932;

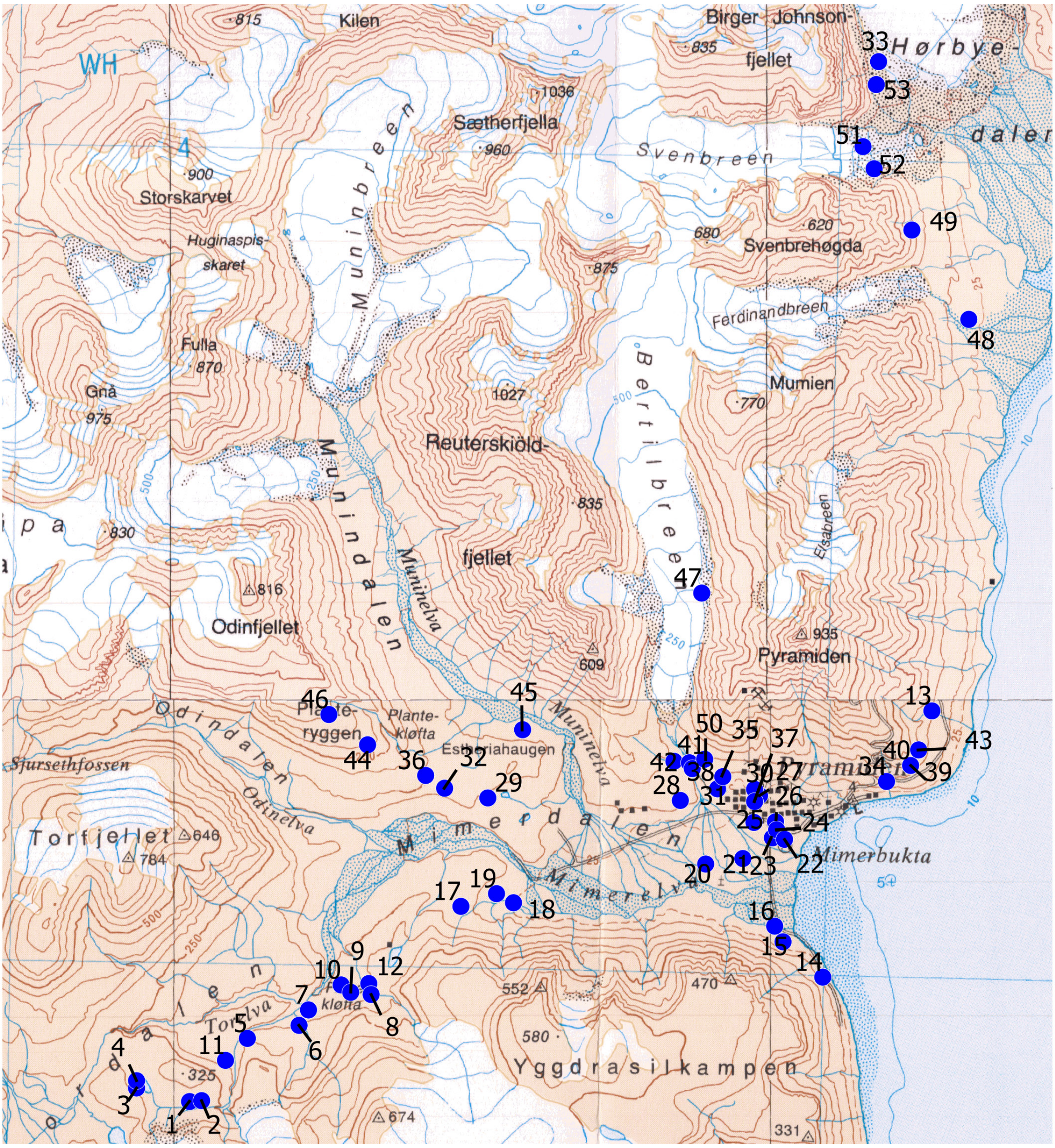

Fig. 1. Map of the area nearby settlement Pyramiden of West Spitsbergen Island, Spitsbergen archipelago; dots are sample plots enumerated. Description of plots see in Table 1.

Table 1. Description of studied localities

No. of locality	Latitude N	Longitude E	Elevation (m a.s.l.)	Description of localities
1	78.6224	16.0113	267	Valley Tordalen. Mountain Jotunrabbane, slope of NW exposure. Fast stream flowing with glacier Jotunfonna. Flooded gravelly plain. On the soil.
2	78.6225	16.0180	267	Valley Tordalen. Mountain Jotunrabbane, slope of NW exposure. Fast stream flowing with glacier Jotunfonna. On the rock in waterfall.
3	78.6238	15.9816	279	Valley Tordalen. Coast of the lake.
4	78.6247	15.9816	285	Valley Tordalen. Coast of the lake. Seepage. On the flooded soil.
5	78.6293	16.0436	219	Mountain Yggdrasilkampen, valley Fiskekløfta. On the soil.
6	78.6307	16.0725	168	Valley Mimerdalen. Mimer river. Wet rock next waterfall. On the sand.
7	78.6333	16.0778	156	Valley Mimerdalen. Mountain Yggdrasilkampen, slope of NNW exposure. Stream. Mats at the bottom on the sand.
8	78.6342	16.1128	180	Valley Mimerdalen. Mountain Yggdrasilkampen, slope of NNW exposure. Snow-fed stream, and seepage on the slope. On the sand or soil.
9	78.6344	16.1013	150	Valley Tordalen. Mountain Jotunrabbane, slope of NW exposure. Wet moss tundra. On the sand between small stones.
10	78.6352	16.0960	138	Mountain Yggdrasilkampen, valley Fiskekløfta. At the bottom of the shallow pool.
11	78.6269	16.0313	175	Valley Tordalen. Stream flowing with glacier Jotunfonna.
12	78.6353	16.1114	180	Valley Mimerdalen. Mountain Yggdrasilkampen, slope of SE exposure. Bank of the snow-fed stream. On the soil.
13	78.6653	16.4263	5	Mountain Pyramiden slope of ESE exposure. Local depression, Coast of the stream. On the soil.
14	78.6361	16.3652	18	Coast of the see. Basis of the mountain Yggdrasilkampen. Fast stream. On the sand.
15	78.6400	16.3430	40	Valley Mimerdalen. Mountain Yggdrasilkampen. Slope of NNW exposure. On the soil.
16	78.6417	16.3384	2	Valley Mimerdalen. Right coast of the river. Basis of the mountain Yggdrasilkampen. Coast of the stream. On the clay.
17	78.6439	16.1630	100	Mountain Yggdrasilkampen. Slope of NNW exposure. Coast of the stream. At the bottom of the shallow pool.
18	78.6443	16.1924	105	Mountain Yggdrasilkampen. Slope of NNW exposure. Flooded moss tundra, between tussocks. On the mosses.
19	78.6453	16.1806	105	Mountain Yggdrasilkampen. Slope of NNW exposure. Small stream. On the stones.
20	78.6485	16.2998	13	Valley Mimerdalen. Wet moss tundra. On the soil.
21	78.6491	16.3206	6	Valley Mimerdalen. On the alluvium (sand).
22	78.6512	16.3439	9	Territory of settlement. Coastal of the see. See marsh. *Puccinellia phryganodes* and *Stellaria humifusa* community. Dark braun mats. On the soil.
23	78.6514	16.3371	2	Coastal of the see. Wet meadow. On the sand.
24	78.6523	16.3395	9	Territory of settlement. Wetland. *Eriophorum scheuchzeri* community. On the soil.

Table 1 (continued)

No. of locality	Latitude N	Longitude E	Elevation (m a.s.l.)	Description of localities
25	78.6531	16.3268	103	Territory of settlement. Anthropogenous meadow about cow-house. On the soil.
26	78.6532	16.3389	9	Territory of settlement. At the bottom of the shallow pool.
27	78.6560	16.3299	9	Territory of settlement. Under bird colony. On the soil.
28	78.6555	16.2856	50	Mountain Reuterskiöldfjellet. Mountain terrace, local depression. Salix and moss comunity. Seepage. On the soil.
29	78.6558	16.1780	98	Mountain Planteryggen. Coastal of the lake. Flooded moss tundra. On the mosses.
30	78.6567	16.3271	25	Territory of settlement. Anthropogenous meadow between two roads On the soil.
31	78.6568	16.3064	16	Territory of settlement. The former stadium. Side slopes. On the soil.
32	78,6568	16.1539	80	Mountain Planteryggen. Slope of N exposure. Rocks. Local depression. On the soil.
33	78.7365	16.3965	100	Petuniabukta bay. Mountain Birger Johnsonfjellet. Slope of E exposure. Valley Hørbyedalen. Bog with tussocks. On the clay.
34	78.6576	16.4009	42	Mountain Pyramiden. Slope of S exposure. Fragmented *Dryas octopetala* community. On the soil.
35	78.6581	16.3093	36	Mountain Pyramiden, submontane stream forming the seepage. Outside the main stream at a relatively dry areas.
36	78.6583	16.1432		Slope of the hill of S exposure. Snow-fed stream. Mats on the rock.
37	78.6554	16.3271	48	Territory of settlement. Under bird colony. On the soil.
38	78.6590	16.2923	71	Mountain Pyramiden. *Dryas octopetala* community. On the soil.
39	78.6594	16.4144		Mountain Pyramiden. Slope of SE exposure. Lichens tundra and *Cassiopa tetragona*, *Dryas octopetala* and *Silene acaulis*. On small hillocks (soil).
40	78.6594	16.4144		Mountain Pyramiden. Slope of SE exposure. Lichens tundra and *Cassiopa tetragona*, *Dryas octopetala* and *Silene acaulis*. On small hillocks (soil).
41	78.6596	16.2907	72	Mountain Pyramiden. Slope of S exposure. *Cassiope tetragona* community. On the soil.
42	78.6598	16.2820	53	Mountain Reuterskiöldfjellet. Slope of S exposure. Stream on the cleft. On the mosses.
43	78.6611	16.4188	88	Mountain Pyramiden. Slope of SSE exposure. Mountain terrace, local depression. On the soil.
44	78.6616	16.1108	259	Mountain Odinfjellet. Plantekløfta valley. Slope of SSE exposure. *Salix polaris*, *Dryas octopetala* and mosses community. On the mosses.
45	78.6633	16.1975	98	Valley Munindalen. Slope of N exposure. Stream. Mats on the rock.
46	78.6650	16.0891	369	Mountain Planteryggen. Slope of SSE exposure. Snow-fed stream forming the seepage.
47	78.6783	16.2976	250	Valley Bertilbreen. Mountain Pyramiden. Slope of W exposure. On the soil between stone.

Table 1 (continued)

No. of locality	Latitude N	Longitude E	Elevation (m a.s.l.)	Description of localities
48	78.7083	16.4469	29	Petuniabukta bay. River flowing from glacier Ferdinandbreen. Mountain Mumien. Mountain terrace. Wet moss tundra. On the soil.
49	78.7181	16.4151	70	Petuniabukta bay. Mountain Svenbrehøgda. Rock 3-5 m in height. In the shade on the rock.
50	78.6600	16.2992	56	Mountain Pyramiden. Slope of S exposure. Stream. *Oxyria digyna* and mosses community.
51	78.7272	16.3877	104	Petuniabukta bay. Valley of river flowing down from glacier Svenbreen. Under rocks. On the soil.
52	78.7248	16.3940	50	Petuniabukta bay. Base of the mountain Svenbrehøgda. Slope of N exposure. Rock 3-5 m height. The wall of SE exposure. On the rock.
53	78.7340	16.3952	100	Petuniabukta bay. Mountain Birger Johnsonfjellet. Slope of E exposure. Small stream.

Hollerbach et al., 1953; Komárek & Anagnostidis, 1998, 2005; Komarek, 2013). Information on habitats and descriptions of localities were submitted into the CYANOpro database (http://kpabg.ru/cyanopro/) (Melechin et al., 2013).

In this study we have attempted to focus on the microhabitat as the primary environment for the distribution of cyanoprokaryotes, with the goal of defining niches for individual species. The term “microhabitat” refers to a small section of the habitat that is spatially homogeneous in both biotic and abiotic factors, i.e., a section of rock, gravelly, soils and other substrata with relatively the same moisture, illumination, etc. For each sample environmental parameters were considered and the habitat type determined (Table 2). To estimate the breadths of ecological niches, the Stephenson’s formula (1988) was used: $NB=1/(n\sum P_{ij}^2)$, where NB – niche breadth, n – the number of habitat types, P_{ij} – the proportion of species i in the habitat type j, which is calculated as the ratio of the number of samples i^{th} species in the j^{th} type to the total number of samples of this species. Thus, for determining niche breadth, the number of habitat types where the taxon was found was taken into account. Values for NB range from 0 to 1.

Floristic similarity was found using the Sørensen index (KS) (recommended, for example, by Wolda, 1981) (weighted pair-group method using arithmetic averaging) in the program module GRAPHS (Novakovskij, 2004): KS = 2a/(2a+b+c), where a – number of species common to both sets, b – number of species unique to the first set, c – number of species unique to the set.

RESULTS AND DISCUSSION

A total of 73 cyanobacterial taxa were identified in the habitats of investigated area (Table 2). Matuła et al. (2007) identified 100 species of Cyanoprokaryota in Revelva valley in the Hornsund Bay. More than 80 morphospecies were registered in Petunia Bay (Komárek et al., 2012). Eleven species are first time records for Spitsbergen flora: *Anabaena inaequalis*, *Calothrix aeruginosa*, *Chroococcus spelaeus*, *C. subnudus, Gloeocapsa rupicola, G. violascea, Gloeothece palea, Leptolyngbya bijugata*, *Lyngbya martensiana, Rivularia coadunate, Trichocoleus sociatus*.

Nostoc commune (58 observations), *Calothrix parietina* (11 observations), *Microcoleus autumnalis* (9 observations) were the most common species in the investigated samples (Table 2).

Cyanoprokaryotes communities are developed mainly in places with high humidity. The highest number of species was found on wet seepages on the slopes (33 species), in slow tundra streams (26 species) and on the wet soils (21 species, table 3). The most common species on the wet slope seepages were *Aphanocapsa* cf. *grevillei* and *Aphanothece saxicola*. *Chroococcus cohaerens* and *Gloeocapsa alpina* were found in three habitats: on seepages, wet soils and on

Table 2. List of cyanoprokaryote taxa found in different habitats[1]

Species	Habitats												NS	NB
	FS	SS	WT	P	S	WS	WR	SM	CL	A	M	BC		
Anabaena inaequalis (Kütz.) Born. et Flah.[2]	-	-	-	-	-	-	-	22	-	-	25	-	**6**	**0,12**
Aphanocapsa muscicola (Menegh.) Wille	-	-	24	-	28	8, 32	-	22	-	-	-	-	**4**	**0,33**
Aphanocapsa parietina Näg.	-	18	-	-	-	-	49	23	-	-	-	-	**3**	**0,25**
Aphanocapsa cf. *fusco-lutea* Hansg.	-	-	-	-	-	32, 40	-	-	-	-	-	-	**2**	**0,08**
Aphanocapsa cf. *grevillei* (Berk.) Rabenh.	-	-	-	-	35	-	-	-	-	-	-	-	**1**	**0,08**
Aphanocapsa sp.	-	-	-	10	28, 46	1	52	-	3	-	-	-	**5**	**0,08**
Aphanothece caldariorum Richter	-	-	-	-	-	32	-	-	-	-	-	-	**2**	**0,08**
Aphanothece castagnei (Bréb.) Rabenh.	-	-	24	-	28	48	-	-	-	-	-	-	**3**	**0,17**
Aphanothece saxicola Näg.	-	-	-	-	28	-	-	-	-	-	-	-	**2**	**0,08**
Calothrix aeruginosa Voronich.[2]	-	42	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Calothrix breviarticulata W. West et G.S. West	-	53	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Calothrix parietina Thur. ex Born. et Flah.	-	18, 42	-	10	28, 46	1, 5, 48	49, 52	-	3	21	-	-	**12**	**0,48**
Chroococcus cohaerens (Bréb.) Näg.	-	-	-	-	28, 46	12	49	-	-	-	-	-	**4**	**0,22**
Chroococcus helveticus Näg.	-	36	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Chroococcus minutus (Kütz.) Näg.	-	45	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Chroococcus pallidus (Näg.) Näg.	-	-	24	-	4, 28	-	3, 4	-	-	-	-	-	**5**	**0,22**
Chroococcus spelaeus Erceg.[2]	-	-	-	-	28	48	49	-	-	-	-	-	**3**	**0,17**
Chroococcus subnudus (Hansg.) Cronb. et Komárek[2]	-	18	-	-	46	-	-	-	-	-	-	-	**2**	**0,17**
Chroococcus tenax (Kirchn.) Hieron.	-	7	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Chroococcus varius A. Braun	-	36	-	10	28	32, 39	3	-	3	-	-	-	**8**	**0,38**
Cyanosarcina sp.	-	-	-	-	4	-	-	-	-	-	-	-	**1**	**0,08**
Dichothrix gypsophila (Kütz.) Born. et Flah.	-	-	-	-	4	-	-	-	-	-	-	-	**1**	**0,08**
Geitlerinema amphibium (C. Ag.) Anagn.	-	-	-	-	28, 35	-	-	-	-	-	-	-	**2**	**0,08**
Gloeocapsa alpina (Näg.) Brand	-	-	-	-	4	32, 39, 40	3	-	3	-	-	-	**6**	**0,22**
Gloeocapsa decorticans (A. Braun) Richt.	-	-	-	10	-	20	-	-	-	-	-	-	**2**	**0,17**

Table 2 (continued)

Species	Habitats												NS	NB
	FS	SS	WT	P	S	WS	WR	SM	CL	A	M	BC		
Gloeocapsa kuetzingiana Näg.	-	-	-	-	28	15, 38, 39	-	-	-	-	-	-	**4**	**0,14**
Gloeocapsa rupicola Kütz.[2]	-	42	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Gloeocapsa sanguinea (C. Ag.) Kütz.	-	-	-	-	46	5	49	-	-	-	-	-	**3**	**0,25**
Gloeocapsa violascea (Corda) Rabenh.[2]	-	7, 53	-	-	28, 46	1, 12, 15, 32, 48	49	-	-	-	-	-	**8**	**0,27**
Gloeothece confluens Näg.	-	17	9	-	-	8, 15, 43	49	-	-	21	-	-	**7**	**0,22**
Gloeothece cyanochroa Komárek	-	-	-	10	28	-	-	-	-	-	-	-	**2**	**0,17**
Gloeothece palea (Kütz.) Rabenh.[2]	-	-	-	-	4	8	-	-	-	-	-	-	**2**	**0,17**
Gloeothece cf. *violacea* Rabenh.	-	-	-	-	46	-	-	-	-	-	-	-	**1**	**0,08**
Gloeothece sp.	-	-	-	-	46	-	-	-	-	-	-	-	**1**	**0,08**
Leptolyngbya bijugata (Kongiss.) Anagn. et Komárek[2]	-	-	-	-	4	-	-	-	-	-	-	-	**1**	**0,08**
Leptolyngbya gracillima (Zopf ex Hansg.) Anagn. et Komárek	-	-	-	-	-	43	-	-	-	-	-	-	**1**	**0,08**
Leptolyngbya cf. *gracillima*	-	-	-	-	28	-	-	-	-	-	-	-	**1**	**0,08**
Leptolyngbya sp.	-	-	-	10	-	-	-	-	-	-	-	-	**1**	**0,08**
Lyngbya martensiana Menegh. ex Gom.[2]	-	-	-	26	-	-	-	-	-	-	-	-	**1**	**0,08**
Microcoleus amoenus (Kütz. ex Gom.) Strunecky et al.	-	-	-	17	-	-	-	-	-	-	-	-	**1**	**0,08**
Microcoleus autumnalis (Trev. ex Gom.) Strunecky et al.	-	36, 53	24	10, 26	35	-	-	-	-	-	25	27, 37	**9**	**0,22**
Microcoleus vaginatus Gom. ex Gom.	-	42, 50, 53	9	-	46	1, 8, 34, 48	49	-	-	-	-	-	7	**0,27**
Nostoc commune Vauch. ex Born. et Flah.	+	7, 13, 17-19, 36, 45, 50	9, 24, 29, 33, 39, 44	10	4, 28, 35, 30, 46	1, 5, 8, 12, 15, 20, 28, 31, 32, 34, 38, 41, 43, 47, 48, 51	49, 52	22, 23	-	16, 21	25	-	**58**	**0,27**
Nostoc microscopicum Carm. ex Born. et Flah.	-	-	-	-	-	-	49	-	-	-	-	-	**1**	**0,08**
Nostoc minutum Desmaz. ex Born. et Flah.	-	-	-	-	-	43	-	-	-	-	-	-	**1**	**0,08**
Nostoc sp.	-	7, 13, 36, 42	-	-	46	15	-	22	3	-	-	-	**9**	**0,22**

Table 2 (continued)

Species	Habitats												NS	NB
	FS	SS	WT	P	S	WS	WR	SM	CL	A	M	BC		
Oscillatoria sancta Kütz. ex Gom.	-	42	-	-	-	-	-	-	-	-	-	-	**2**	**0,08**
Oscillatoria simplicissima Gom.	-	-	-	10	-	-	-	-	-	-	-	-	**1**	**0,08**
Oscillatoria tenuis C. Ag. ex Gom.	-	6, 19, 45	33	-	46	-	-	-	-	-	-	-	**5**	**0,19**
Oscillatoria cf. *limosa* C. Ag. ex Gom.	-	36	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Oscillatoria sp.	-	8, 36	-	-	-	-	-	-	-	-	-	-	**2**	**0,08**
Petalonema incrustans [Kütz.] Komárek	-	-	-	-	-	32	-	-	-	-	-	-	**2**	**0,08**
Phormidium kuetzingianum (Kirchn.) Anagn. et Komárek	-	17, 45	-	-	46	-	-	-	-	-	-	-	**4**	**0,13**
Phormidium uncinatum Gom. ex Gom.	-	42	-	10	-	-	-	-	-	-	-	-	**4**	**0,22**
Phormidium cf. *calcareum* Kütz.	-	-	-	-	-	-	-	23	-	-	-	-	**1**	**0,08**
Phormidium sp.	-	-	-	-	-	32	-	22, 23	-	-	-	-	**8**	**0,13**
Pseudanabaena frigida (Fritsch) Anagn.	-	-	24	-	-	-	-	22	-	21	25	27	**8**	**0,27**
Rhabdoderma irregulare (Naum.) Geitl.	-	-	-	-	-	12	-	-	-	-	-	-	**1**	**0,08**
Rivularia coadunata (Somm.) Foslie[2]	-	18, 19	-	-	-	-	-	-	-	-	-	-	**3**	**0,08**
Schizothrix arenaria (Berk.) Gom.	-	36	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Schizothrix facilis (Skuja) Anagn.	2	-	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Schizothrix tinctoria (C. Ag.) Gom.	-	42	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Schizothrix sp.	-	36	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Scytonema myochrous (Dillwyn) C. Ag. ex Born. et Flah.	-	-	-	-	28	-	-	-	-	-	-	-	**1**	**0,08**
Scytonema ocellatum Lyngb. ex Born. et Flah.	-	7	-	-	-	32	-	-	-	-	-	-	**2**	**0,17**
Spirulina tenerrima Kütz. ex Gom.	-	-	24	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Stigonema ocellatum (Dillw.) Thur. ex Born. et Flah.	-	36	-	-	-	5	-	-	-	-	-	-	**1**	**0,08**
Tolypothrix distorta Kütz. ex Born. et Flah.	-	18	-	-	-	-	-	-	-	-	-	-	**2**	**0,08**
Tolypothrix limbata Thur. Born. et Flah.	-	-	-	-	-	-	52	-	-	-	-	-	**1**	**0,08**

Table 2 (continued)

Species	Habitats												NS	NB
	FS	SS	WT	P	S	WS	WR	SM	CL	A	M	BC		
Tolypothrix saviezii Kossinsk.	-	-	-	-	28	-	-	-	-	-	-	-	**1**	**0,08**
Tolypothrix tenuis Kütz. ex Born. et Flah.	6	-	-	-	-	-	-	-	-	-	-	-	**1**	**0,08**
Tolypothrix sp.	-	-	-	-	13, 46	-	-	-	-	-	-	-	**2**	**0,08**
Trichocoleus sociatus (W. West et G. S. West) Anagn.[2]	-	-	-	10	-	-	-	23	-	21	-	-	**3**	**0,25**

[1] – Numbers within the columns correspond to the locality numbers in Table 1; [2] – first records for Spitsbergen flora. Habitats: FS – fast running glacial streams and waterfalls; SS – slow running tundra streams; WT – wet moss tundra; P – tundra pools; S – seepages; WS – wetted soils; WR – wet and dripping rocks; SM – coastal to the sea, sea marsh; CL – coast of the lake; A – alluvium on the riverside; M – meadow about cow-house, on the soil; BC – under bird colony, on the soil. NS – number of samples; NB – values for niche breadth.

the rocks. The most common taxa on the soil were *Calothrix parietina*, *Microcoleus vaginatus*, *Nostoc commune*. Only on wet soils were found *Aphanocapsa* cf. *fusco-lutea* and *Stigonema ocellatum*. At the bottom of the slow running streams cyanobacterial communities were dominated by *Phormidium uncinatum*. A total of 26 species of cyanoprokaryota were found on the slow running streams.

Most similar was the species composition of the meadow nearby cow-house and on the soils under the bird colony, wet tundra habitat were included in this cluster also (Fig. 2). Species composition on the wet soil and wet rocks habitats was similar. More than half of the species are common on the sea marsh and alluvium on the riverside habitats.

The smallest width of ecological niche (NB = 0.08) was typical for most species (37), e.g. *Rivularia coadunata*. *Calothrix parietina* (NB = 0.48), *Chroococcus varius* (0.38), *Aphanocapsa muscicola* (0.33) had the widest ecological amplitudes – these species had the greatest ecological flexibility in the studied habitats. We have pointed out earlier that *Calothrix parietina* shows wide ecological plasticity (NB = 0.593) in

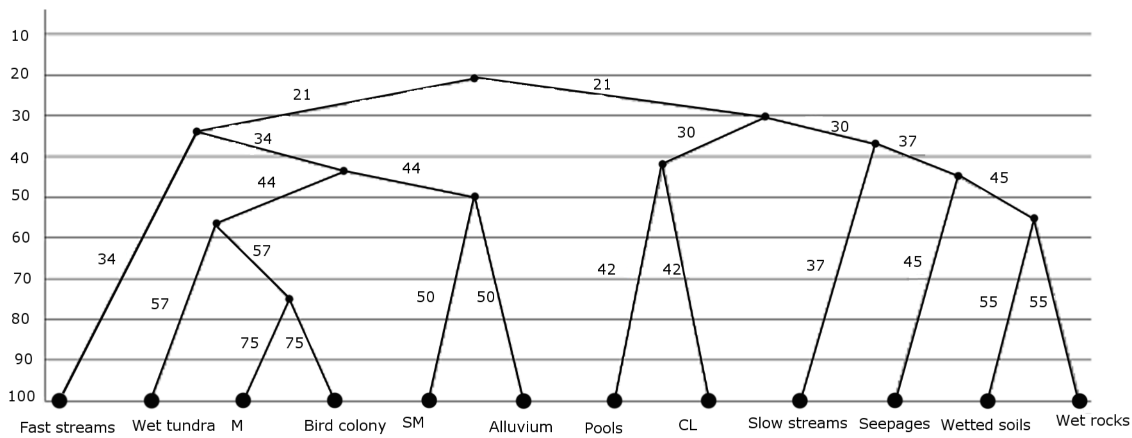

Fig. 2. Complete graph, based on Sørensen index, of floristic similarity of habitats; for clustering the mean distance (weighted pair-group method using arithmetic averaging) between elements of each cluster was used. Numbers show similarity in percent (scale from 0 to 100); M – meadow about cow-house, on the soil; CL – coast of the lake; SM – coastal of the sea, sea marsh.

the Grønfjorden west coast (Davydov, 2011). Thus, the width of the ecological niche does not depend on the study area, and is an objective characteristic of this taxa.

Nostoc commune has, despite the high frequency of occurrence (in 23% of samples) and wide distribution in the study area, a relatively narrow ecological niche (NB = 0.27). This shows that a narrow optimum zone of species is on the different wet soils, but pessimum zone can be fairly wide (it can grow in streams and seepages).

Cyanobacterial floras in various territories of the Svalbard area differ from each other (Fig. 3). Most similar (the difference in species composition over 60 %) are the flora of the Grønfjorden west coast and flora of the Rijpfjorden east coast, however, only less than 1/3 of species are common.

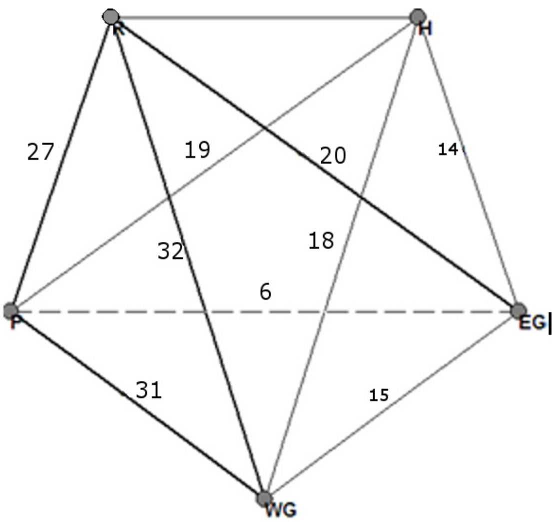

Fig. 3. Complete graph, based on Sørensen index, of floristic similarity between Svalbard areas; for clustering the mean distance (weighted pair-group method using arithmetic averaging) between elements of each cluster was used. Numbers show similarity in percent (scale from 0 to 100): P – flora of the vicinity settlement Pyramiden, R – flora of the Rijpfjorden east coast (Davydov, 2013), WG – flora of the Grønfjorden west coast (Davydov, 2011), EG – flora of the Grønfjorden east coast (Davydov, 2008), H – flora of the Revelva valley (Matuła et al., 2007).

CONCLUSIONS

A total of 73 cyanobacterial taxa were identified in the investigated area. Eleven species are first records for Spitsbergen flora. Cyanoprokaryotes in the vicinity of settlement Pyramiden were found in 12 habitat types. They were mostly confined to the hydro-terrestrial environments (Elster, 2002): wet slope seepages, wet soils, slow running tundra streams and pools. No species occured in all microhabitats. *Nostoc commune* (in 23% of samples) and *Calothrix parietina* (in 4.5% of samples) dominated in the most of habitats. *Calothrix parietina*, *Chroococcus varius*, *Aphanocapsa muscicola* had the widest ecological amplitude and the greatest ecological flexibility in the studied habitats.

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