ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Species Composition of Planktonic Algae of Termokarst Lakes of Khatanga River Basin (Krasnoyarsk Region, Russia).

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ABSTRACT

Objective of this study was to determine the species composition of modern planktonic algae in the range of thermokarst lakes of Khatanga River basin (Krasnoyarsk region, Russia). The Khatanga River flows in the North-Siberian lowland in the south-eastern part of the Taimyr Peninsula and flows into the Khatanga Gulf of the Laptev Sea. The river basin has about 112 thousand lakes with a total area of 12 thousand sq.km. Today, M.K. Ammosov North-Eastern Federal University (Yakutsk), A. Wegener Institute for Marine and Polar Research (AWI, Potsdam, Germany), and Kazan Federal University has entered into agreement on cooperation in the sphere of science and higher professional education. In the framework of this agreement, in August 2013, an expedition was conducted to study the limnological characteristics of the lakes in Yakutia in order to reconstruct the Holocene history, during which the algological water samples from and hydro-chemical and morphometric data on 18 lakes were obtained. During the observation period, we found 164 algae taxa belonging to 6 different groups in phytoplankton of the investigated water bodies. The greatest number of taxa were identified in the groups of diatoms and chlorococcaceae. According to the ecological and geographical characteristics, the dominant species in these lakes are cosmopolitan and boreal algae. In relation to halobility, most species are indifferent and oligohalobic, and in terms of pH the most common are the indifferent and alkaliphile + alkalibiontic organisms.

Keywords: phytoplankton, algae, thermokarst lakes, the Khatanga River basin, Krasnoyarsk region of Russia, Yakutia.

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INTRODUCTION

In recent years, an interest in studying the Eurasian North has significantly increased, which is due, first of all, to the problem of global climate change. The polar regions of the Northern Hemisphere have a large number of lakes of various genesis and morphometry, having archived in their sediments a detailed information about the climate, landscape and hydrology in the Pleistocene and Holocene. Due to their geographical position, the polar lakes were poorly investigated for a long time, and only in recent decades an active research work started on studying the stratigraphy of sediments of the lakes and the reconstruction of the past paleogeographic and paleoclimatic environments. Paleoecological evaluation, as well as information about the current state of these water bodies allows identifying the main patterns of change in the natural environment of the lake catchment basin during the Holocene and Late Pleistocene, as well as optimally using natural resources and predicting the evolution of the cryogenic lake landscape under increasing global anthropogenic warming of the North climates.

To date, a number of paleogeographic studies of the lakes in Yakutia [1-10] has been conducted, but there is very little information on the current state of these lakes. According to data on species composition, trophic structure and production characteristics of aquatic organisms, and especially of planktonic algae - phytoplankton, as primary producers, it is possible to define the organizational characteristics of the aquatic ecosystems.

Objective of this study was to determine the species composition of modern planktonic algae in the range of the lakes of Khatanga River basin (Krasnoyarsk region, Russia). Such studies of planktonic algae were conducted for the first time in this area.

MATERIAL AND RESEARCH METHODS

In August 2013 an expedition for the purpose of reconstruction of the Holocene history was conducted as part of an international research expedition "Khatanga 2013" aimed at studying the limnological characteristics of the lakes of Yakutia, during which its participants obtained the algological water samples from 18 thermokarst lakes of the Khatanga River basin in the Taimyr Dolgan-Nenets district (Fig. 1, Table. 1).

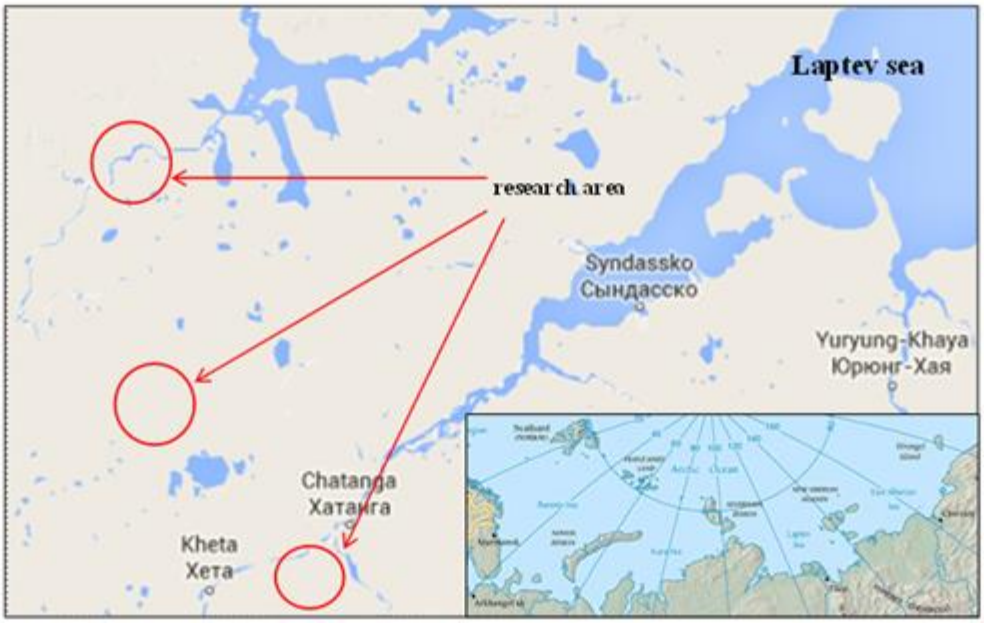

Fig. 1. Location map of water sampling stations in the lakes of the Khatanga River basin (Krasnoyarsk region, Russian Federation).

Table 1. Geographical coordinates of the studied lakes of the Khatanga River basin (Krasnoyarsk region, Russian Federation, 2013).

Lake No.	Latitude (°)	Longitude (°)
1	72.5575	105.72706
2	72.4883	105.64833
3	72.40078	105.43985
4	72.40615	105.44247
5	72.41184	105.46357
6	72.41291	105.44771
7	72.39159	105.44349
8	72.18103	104.48785
9	71.4031	102.28264
10	71.11221	100.85285
11	71.10669	100.82288
12	71.09708	100.85389
13	71.10383	100.87602
14	71.09591	100.79747
15	72.14929	102.05598
16	72.15327	102.07542
17	72.13599	102.06801
18	72.12775	102.03437

Physico-geographical and hydrological characteristics of the Khatanga River and the research area.

The Khatanga River (Krasnoyarsk region, Russian Federation) flows in the North-Siberian lowland in the south-eastern part of the Taimyr Peninsula and flows into the Khatanga Gulf of the Laptev Sea. Length of the river is only 227 km, however, if starting from the source of the river Kotuy, its length will exceed 1,600 km. The bed of the river Khatanga lies entirely in the permafrost area [1]. The river basin has about 112 thousand lakes with a total area of 11.6 thousand sq.km. Lakes often lie in the thermokarst cavities or depressions in the floodplains and on the river islands.

Climate of Krasnoyarsk Territory within the Khatanga river basin is sharply continental, characterized by strong temperature fluctuations during the year. The soil composition is mainly represented by permafrost-taiga, mountain taiga, podzolic taiga, and mountain tundra soils.

Morphometric and hydrochemical indicators of the studied lakes.

During the expedition, hydro-chemical parameters of each water body such as conductivity, alkalinity, oxygen content, pH, redox potential, temperature and Secchi-disk water transparency were measured. There was recorded the presence of higher aquatic vegetation, the size and depth of the studied water body. These data were published in previous reports [11].

Among the studied water bodies, the largest and the deepest were number 7 and 11. Most lakes, in spite of their relatively small size, were quite deep, up to 6-9 m. Some lakes are shallow, with a depth not exceeding 3 m. All the lakes are characterized by a high Secchi-disk transparency (4-7 m). Most lakes have vertical stratification of the water temperature, content of dissolved oxygen, and pH values.

The content of water-dissolved oxygen was close to saturation or greater than its threshold. The water temperature in the lakes varied significantly. In contrast to the small shallow lakes, the deep lakes do not have time to warm up: the water temperature of the warmed surface layers during the study period was in the range of 13-18°C. By pH, most of the lakes were neutral (pH 6.5-7.5), a small part of the lakes - weakly alkaline (pH 7.5-8.5). PH value (pH) ranged 7.3 to 8.67.

During the study period, total 36 quantitative and qualitative samples of planktonic algae were collected. Selection and office processing of phytoplankton samples were carried out according to standard method [12-13]. Phytoplankton samples were collected from a depth of 1 - 1.5 m. All quantitative samples of 0.5L were fixed with 4% formalin solution. Qualitative samples were collected with a small Apstein net (mesh size - 7 microns), by filtering 10 liters of water. The fixed samples were further concentrated by settling method up to 7 - 10 ml.

RESULTS AND DISCUSSIONS

Composition and ecologically floristic characteristic of algae.

During the observation period of 2013, we found 164 planktonic algae taxa belonging to 6 different groups in phytoplankton of the investigated water bodies. Data on phytoplankton taxonomic structure are shown in Table 2. The most prevalent algae in the species diversity are Bacillariophyta (48.2%) and Chlorococcales (32.9%). Other groups are less diverse: Cyanobacteria - 8.5%, Euglenophyta - 4.3%, Chrysophyta - 2.4% and Dinoflagellate - 3.7%.

The highest species diversity is typical of the genera of cyanobacteria *Gloeocapsa, Gomphosphaeria,* diatoms *Stephanodiscus, Cyclotella, Aulacoseira, Fragilaria, Diatoma, Tabellaria, Navicula, Pinnularia, Neidium, Achnanthes, Eunotia, Cymbella, Gomphonema, Epithemia, Rhopalodia, Nitzschia, Surirella, Cymatopleura,* dinophytes *Peridinium,* euglenophytes *rachelomonas, Euglena,* and chlorophytes *Chlamydomonas, Pediastrum, Dictyosphaerium, Coelastrum, Scenedesmus, Crucigenia, Ankistrodesmus, Monoraphidium, Cosmarium, Staurastrum*.

The most often observed are the species of Cyanobacteria, Chrysophyta, Chlorococcales and Dinoflagellate (Fig. 2). Diatoms were found not in all water bodies, perhaps, due to the fact that only the plankton samples were selected, and the sampling period made a difference. The Species diversity of diatoms was quite high, despite the fact that no their high concentrations have been identified - half of the total number of the encountered phytoplankton species.

Table 2. List of taxa of planktonic algae of the lakes in the Khatanga River basin (2013)

	Taxon / Lake No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Cyanophyta																		
	Cyanophyceae																		
	Chroococcales																		
1	*Chroococcus turgidus* (Kütz.) Nägeli											+							
2	*Gloeocapsa limnetica* (Lemm.)Hollerb.						+					+							
3	*Gloeocapsa turgida* (Kiitz.) Hollerb. Emend.											+							
4	*Gloeocapsa minor* (Kiitz.) Hollerb. ampl.													+					
5	*Gomphosphaeria lacustris* Chod.											+				+		+	+
6	*Gomphosphaeria lacustris* f. *compacta* (Lemm.) Elenk.											+							
	Oscillatoriales																		
7	*Oscillatoria planctonica* Wotosz.									+		+						+	
8	*Oscillatoria* sp.																		
9	*Lyngbya limnetica* Lemm.																		+
	Nostocales																		
10	*Anabaenopsis* sp.																	+	+
11	*Anabaena flos-aquae* Breb.																	+	+
12	*Anabaena flos-aquae f. aptekariana* Elenk.								+										
1	*Anabaena scheremetievi* Elenc.			+	+	+	+		+	+	+	+	+	+	+	+	+		

3																			
14	*Aphanizomenon flos-aquae* (l.) Ralfs.			+			+				+							+	+
	Dinophyta																		
	Dinophyceae																		
	Gymnodiniales																		
1	*Gymnodinium* sp.						+												
	Peridiniales																		
2	*Peridinium aciculiferum* Lemm.			+	+				+							+			+
3	*Peridinium bipes* Stein.	+						+								+			
4	*Peridinium palatinum* Lauter.	+			+		+		+			+					+	+	
5	*Peridinium* sp.2	+																	
	Gonyaulacales																		
6	*Ceratium hirundinella* (O.P.M.) Schrank.	+						+	+										
	Chrysophyta																		
	Chrysophyceae																		
	Chromulinales																		
1	*Chromulina* sp.						+											+	
2	*Dinobryon divergens* Imhof.	+	+		+	+	+	+	+		+	+						+	
3	*Pseudokephyrion* sp.	+	+	+														+	
	Synurophyceae																		
	Synurales																		
4	*Synura* sp.				+														
	Bacillariophyta																		
	Coscinodiscophyceae																		
	Thalassiosirales																		
1	*Stephanodiscus hantzschii* Crun.		+																
2	*Stephanodiscus rotula* (Kiitz.) Hendey.		+																
3	*Stephanodiscus minutulus* (Kiitz.) Cleve et Moller.												+						
4	*Cyclostephanos dubius* (Fricke) Round.	+																	
5	*Cyclotella meneghiniana* Kiitz.	+							+										
6	*Cyclotella comta* (Ehr.) Kiitz.													+					
	Melosirales																		
7	*Melosira varians* Ag.																+		
	Aulacoseirales																		
8	*Aulacoseira ambigua* (Grun.) Sim.												+						
9	*Aulacoseira granulata* (Ehr.) Sim.													+					
10	*Aulacoseira islandica* (O. Mull.) Sim.																	+	
11	*Aulacoseira italica* (Kiitz.) Sim.												+	+				+	
12	*Aulacoseira distans* (Ehr.) Sim.																	+	
	Bacillariophyceae																		
	Fragilariales																		

13	*Hannaeaarcus arcus* var. linearis (Holmboe) Patr.																		+
14	*Fragilaria construens* (Ehr.) Grun.																		+
15	*Fragilaria crotonensis* Kitt.																+		
16	*Synedra ulna* (Nitzsch.) Ehr.									+			+						+
17	*Asterionella formosa* Hass.							+								+	+	+	
18	*Diatoma elongatum* (Lyngb.) Ag. var. *elongatum*																		+
19	*Diatoma vulgare* Bory.											+							
20	*Diatoma anceps* (Ehr.) Kirchn.											+							
	Tabellariales																		
21	*Tabellaria fenestrata* (Lyngb.) Kiitz.										+							+	+
22	*Tabellaria fllocculosa* (Roth.) Kutz.																	+	+
	Naviculales																		
23	*Aneumastus stroesei* (Ostrup) Mann.								+										
24	*Navicula cryptocephala* Kiitz.								+										
25	*Navicula peregrina* (Ehr.) Kiitz.																	+	
26	*Navicula radiosa* Kiitz.														+				
27	*Navicula reinhardtii* (Grun.) Grun.															+			
28	*Navicula rhynchocephala* Kiitz.							+											
29	*Navicula rrhynchocephala* Kiitz. var. *rhynchocephala*										+								
30	*Navicula* sp.																		+
31	*Stauroneis anceps* var. *anceps* Ehr.																+	+	
32	*Stauroneis* sp.																	+	
33	*Gyrosigma acuminatum* (Kiitz.) Rabenh.															+			+
34	*Pinnularia borealis* Ehr.							+	+						+	+		+	
35	*Pinnularia interrupta* W Sm.					+													
36	*Pinnularia legumen* (Ehr.) Ehr.																	+	
37	*Pinnularia* sp.										+							+	
38	*Caloneis amphisbaena* (Bory) Cl.									+									
39	*Neidium affine* (Ehr.) Pfitz.												+				+		
40	*Neidium dubium* (Ehr.) Cl..										+								
	Achnanthales																		
41	*Cocconeis placentula* Ehr.						+			+	+							+	
42	*Achnanthes lanceolata* (Breb.) Grun.										+						+		
43	*Achnanthes ploenensis* var. *gessneri* (Hustedt).						+												
44	*Achnanthes* sp.	+																	

	Eunotiales																		
45	*Eunotia fallax* A. Cl.																		
46	*Eunotia tenella* (Grunow) Hust. in A. Sch.								+			+							
47	*Eunotia meisteri* Hust.																		+
48	*Eunotia exigua* (Bréb. ex Kütz.) Rabenh.								+										
49	*Eunotia bilunaris* (Ehrenb.) Mills.											+							
50	*Eunotia* sp.									+									+
	Cymbellales																		
51	*Cymbella affinis* Kiitz.		+																
52	*Cymbella cistula* (Ehr.) Kirchn.				+														
53	*Cymbella* sp. 1																	+	
54	*Cymbella* sp. 2	+																	
55	*Gomphonema acuminatum* Ehr.					+													
56	*Gomphonema olivaceum* (Lyngb.) Kiitz.							+											
	Thalassiophysales																		
57	*Amphora ovalis* Kiitz.																	+	+
	Rhopalodiales																		
58	*Epithemia* sp.	+																	
59	*Epithemia turgida* (Ehr.) Kiitz.		+																
60	*Rhopalodia gibba* (Ehr.) O. Miil.						+												
61	*Rhopalodia* sp.									+									
	Bacillariales																		
62	*Nitzschia acicularis* W.Sm.																	+	
63	*Nitzschia draveillensis* Coste et Ricard.																	+	
64	*Nitzschia palea* (Kiitz). W.Sm.																+		
65	*Nitzschia paleacea* Grun.															+			
66	*Nitzschia recta* Hantzsch.																		+
67	*Nitzschia sigmoidea* (Nitzsch.) W.Sm.																+		
68	*Nitzschia vermicularis* (Kiitz.) Grun.																+		
69	*Nitzschia* sp.			+															
70	*Hantzschia amphioxys* (Ehr.) Grun.																		
71	***Surirellales***																		
72	*Surirella angustata* Kiitz.	+																	
73	*Surirella brebissonii* Krammer et Lange-Bertalot.							+											
74	*Surirella minuta* Breb.									+									
7	*Surirella didyma* Kütz.																		+

5																			
76	*Surirella linearis* W.Sm.											+							
77	*Cymatopleura elliptica* (Breb.) W.Sm.																		
78	*Cymatopleura solea* (Breb.) W.Sm.													+					
79	*Campylodiscus hibernicus* Ehr.										+								
	Euglenophyta																		
	Euglenophyceae																		
	Euglenonales																		
1	*Trachelomonas hispida* (Perty.) Stein emend. Defl.			+															
2	*Trachelomonas intermedia* Dang.	+					+			+							+	+	+
3	*Trachelomonas planctonica* Swir.		+	+						+		+	+	+	+	+	+	+	
4	*Trachelomonas volvocina* Ehr.									+	+			+				+	
5	*Euglena acus* Ehr.																	+	
6	*Euglena viridis* Ehr.						+					+							
7	*Euglena* sp. 1																		+
	Chlorophyta																		
	Chlorophyceae																		
	Volvocales																		
1	*Asterococcus superbus* (Cienk.) Scherff.						+											+	
2	*Chlamydomonas globosa* Snow.																+		
3	*Chlamydomonas* sp.	+		+		+													
4	*Chlorogonium elongatum* Dang.										+	+							
5	*Pandorina morum* (Mill.) Bory.			+			+					+							
6	*Eudorina elegans* Ehr.														+				
7	*Carteria* sp.																		+
	Chlorococcales																		
8	*Chlorococcum* sp.							+											
9	*Sphaerocystis planctonica* (Korsch.) Bourr.								+										
10	*Pediastrum boryanum* (Turp.) Menegh.						+				+	+			+	+	+	+	
11	*Pediastrum duplex* Meyen.															+			
12	*Coenococcus planktonicus* Korschik.												+						
13	*Dictyosphaerium pulchellum* Wood.	+	+	+		+	+				+				+	+		+	
14	*Dictyosphaerium* sp.	+	+	+							+	+							
15	*Coelastrum cambricum* Arch.						+											+	
16	*Coelastrum proboscideum* Bohl.																	+	
17	*Scenedesmus acuminatus* (Lagerh.) Chod.			+															
18	*Scenedesmus denticulaus* Lagerheim. (var. disciformis Hortobagyi.)	+																	
19	*Scenedesmus disciformis* (Chod.) Fott et Kom.		+																
2	*Scenedesmus guadricauda* (Turp.) Breb.														+				+

0																			
21	*Scenedesmus naegelii* Breb.										+	+		+	+				
22	*Scenedesmus* sp.			+															
23	*Tetrastrum alpinum* Korschik.			+														+	
24	*Crucigenia tetrapedia* (Kirchn.) W.et.W.					+									+			+	
25	*Crucigenia rectangularis* (A..Br.) Gay.										+								
26	*Ankistrodesmus angustus* Bern.																+		
27	*Ankistrodesmus falcatus* (Corda.) Ralfs.					+													
28	*Ankistrodesmus fusiformis* Corda.													+				+	
29	*Monoraphidium contortum (Thur. in Bréb.) Komárk.-Legn.*										+								+
30	*Monoraphidium arcuatum* (Korsch.) Hind.						+					+	+						
31	*Monoraphidium minutum* (Nag.) Kom.-Legn.			+															
32	*Monoraphidium sp.*																		
	Trebouxiophyceae																		
	Trebouxiales																		
33	*Botryococcus* Kütz.						+			+				+					
	Oocystales																		
34	*Oocystis natans* Wille.			+			+		+		+	+	+	+	+		+	+	
	Zygnematophyceae																		
	Zygnematales																		
35	*Euastrum elegans* (Bréb.) Kütz. ex Ralfs.			+				+			+				+				
36	*Cosmarium botrytis* Menegh.							+											
37	*Cosmarium lundelly* Breb.						+							+					
38	*Cosmarium margaritiferum* Menegh.										+	+							
39	*Cosmarium granatum* Breb.						+												
40	*Cosmarium blyttii* Will.			+								+							
41	*Cosmarium depressum* (Nägeli) J.W.G. Lund.											+							
42	*Cosmarium humile* (Gay.) Nordst.										+								
43	*Cosmarium* sp.1												+						
44	*Cosmarium* sp.2															+			
45	*Staurastrum brachiatum* Ralfs.										+								
46	*Staurastrum paradoxum* Meyen.												+						
47	*Staurastrum gracil* Ralfs.															+			
48	*Staurastrum setigerum* Cleve.										+								
49	*Staurastrum planctonicum* Teil.					+							+						
5	*Staurastrum sexangulare* (Bulnh.) P. Lund.											+							

0																			
51	*Staurastrum* sp.					+													
52	*Staurodesmus dejectus* (Breb.) Teil. var.*apicularis*		+															+	
53	*Spondylosium planum* (Wolle) West & G.S.West.		+										+	+		+		+	
54	Sp. sp.																		

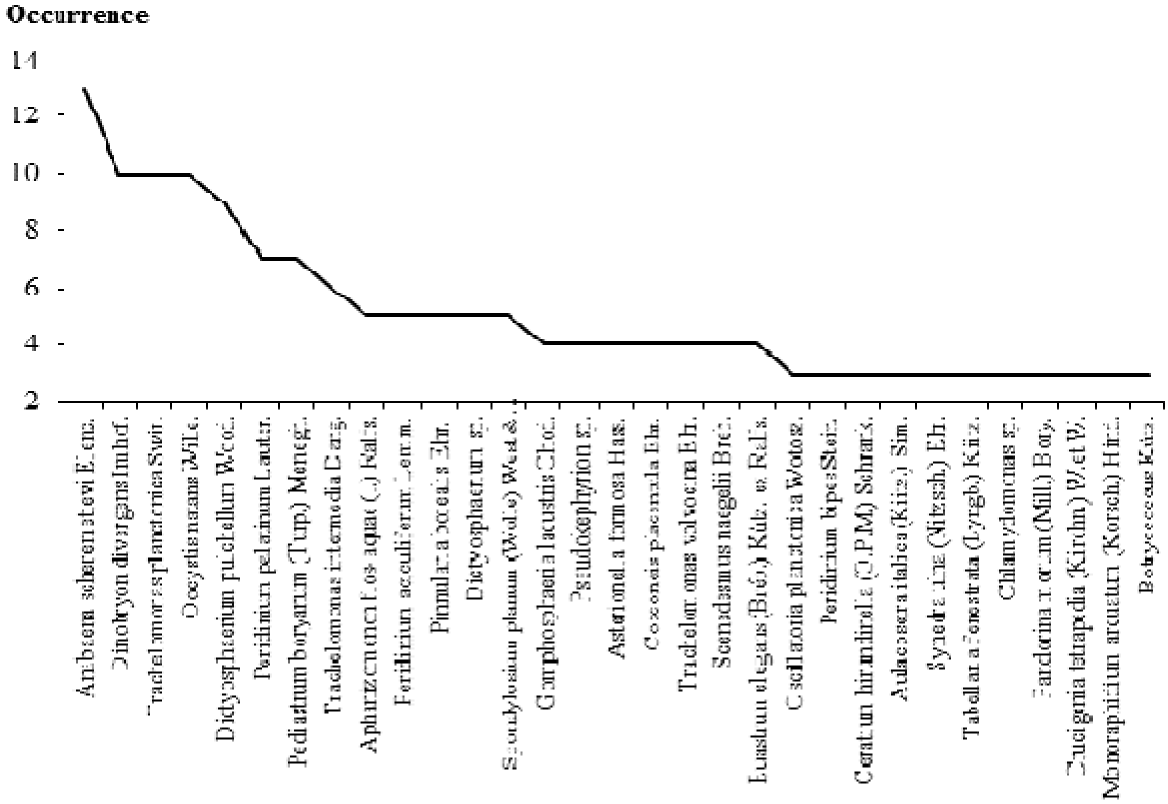

Fig. 2. Occurrence rate of phytoplankton taxa of the lakes in the Khatanga River basin (2013): the figures on the Y-axis indicate the occurrence rate of the species in the studied water bodies

SUMMARY

The main object of this research was phytoplankton of the water column. The planktonic algae in the investigated shallow waters are represented by several environmental groups that differ in species composition, growth conditions, growth dynamics, etc. and include phytoplankton, epipelon, epiphytic algae and free-floating filaments or accumulations of filamentous algae. The dominating species in the planktonic communities were algae with a wide environmental range, capable to live within the plankton and benthos (Table 3).

Table 3. Ecologically geographical characteristics of common species of phytoplankton of the lakes in the Khatanga River basin (2013)

Groups	lake No.																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Habitats																		
Planktonic	8	7	10	4	4	12	3	8	6	13	14	10	10	7	11	11	24	9
Littoral	1	2	–	1	1	4	2	2	2	2	5	1	1	–	–	3	5	5
Benthic-planktonic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–

Fouling inhabitant	–	1	–	–	–	2	–	1	1	2	1	–	–	–	1	1	1	1
Benctic	–	–	–	–	2	–	1	1	1	1	–	1	–	2	2	1	2	–
Geographical distribution																		
Cosmopolite	7	9	11	3	7	15	5	8	10	9	17	8	9	7	12	13	23	13
Boreal	1	1	–	1	–	1	–	–	–	–	–	2	1	1	2	–	3	1
Biographically poorly	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	1	–
North-Alpine	–	–	–	–	–	–	1	2	–	1	2	1	1	1	1	–	4	1
Halobity categories																		
Indifferent	5	6	7	3	6	11	4	7	6	14	14	11	7	7	11	11	21	9
Halophobe	–	1	–	–	–	–	–	1	–	–	2	–	–	–	–	–	3	–
Oligohalobe	2	1	3	1	1	5	2	1	1	4	1	–	–	2	4	2	5	5
Halophile	1	1	–	–	–	1	–	1	3	1	1	–	3	–	–	2	1	1
Mesohalobe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
PH indicator categories																		
Indifferent	4	5	3	2	2	6	2	4	4	7	5	3	2	4	7	6	14	6
Alkaliphile + alkalibiont	3	4	3	2	2	3	2	3	4	4	3	4	4	2	6	9	5	4
Acidophile + acidobiont	–	–	–	–	1	–	–	1	–	–	2	–	–	–	–	–	2	1
Saprobity																		
Beta-mesosaprobe	4	4	6	1	4	7	–	1	4	8	4	4	6	5	7	9	10	6
Oligo-betamesosaprobe	1	2	1	1	2	1	2	1	1	1	2	1	1	1	5	2	7	5
Beta-alfamesosaprobe	–	–	1	–	–	–	1	–	1	1	–	–	–	–	1	–	–	2
Oligo-alfamesosaprobe	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2	–
Alfa-polysaprobe	–	1	–	–	–	1	–	–	–	–	1	–	–	–	–	–	–	–
Oligosaprobe	–	–	–	–	–	3	–	2	–	–	5	1	–	–	–	1	3	–
Alfa-mesosaprobe	1	–	–	–	–	–	–	2	1	2	1	1	–	–	–	1	1	–
Beta-oligosaprobe	–	1	–	–	–	1	–	–	1	1	–	–	–	–	–	–	1	–
Oligo-xenosaprobe	–	–	–	–	–	–	1	1	–	–	–	–	–	1	1	–	2	1

According to the ecological and geographical characteristics, the dominant species in these lakes are cosmopolitan and boreal algae. In relation to halobility, most species are indifferent and oligohalobic, and in terms of pH the most common are the indifferent and alkaliphile + alkalibiontic organisms. During the research, no species new or rare for the flora of the region were identified. There are also taxa that require further clarification and identification at the species level.

CONCLUSION

Based on these results, it is possible to answer some questions. Environmental assessment of the current state of the tundra lake ecosystems makes it possible to study the dynamics of the state of the lake ecosystems in the past, and mainly identify the nature of the reaction of natural Arctic ecosystems (using tundra as example) to the global climate change. The obtained results can be also applied in the development of predictive models of polygonal tundra landscape change in a changing climate, based on the information on quantitative ecology of biotic components of modern terrestrial and aquatic ecosystems, autecological and synecological patterns of biotic components of the tundra ecosystems.

ACKNOWLEDGEMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

The authors express their sincere gratitude to all the participants of the international expedition "Khatanga 2013", especially its leader Prof. Dr. Ulrike Herzschuh. KLY and FLA were supported by Russian Government Program of Competitive Growth of Kazan Federal University. The part of this work was supported by grant from Russian Scientific Foundation (project 15-05-04442).

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