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Phytoplankton Community Structure of Thermokarst Lakes from Khatanga River Basin (Krasnoyarsk Region, Russia).

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ABSTRACT

Planktonic algae - phytoplankton - is a key component of water systems, actively involved in the formation of the water quality, and a sensitive indicator of the state of aquatic ecosystems and the water body as a whole. We have studied phytoplankton of several thermokarst lakes of northern areas of Krasnoyarsk region. Samples for phytoplankton analysis were selected during the comprehensive limnological and palaeolimnological Russian-German expedition in August 2013, from 18 lakes. This report presents qualitative and quantitative indicators of phytoplankton, as well as evaluation of the current ecological status of water by the parameters phytoplankton of several thermokarst lakes of the Khatanga river basin. During the observation period, we found 164 planktonic algae taxa in phytoplankton of the investigated water bodies. Quantitative indicators of the phytoplankton of the studied lakes are low, the total abundance and biomass of phytoplankton varies from 31.50-2,331.50 thousand Cl./L and 0.05-1.01 mg/L. The most prevalent in number are green-blue algae, and in biomass - dinoflagellate, green and golden algae. Water of most thermokarst lakes of the Khatanga river basin during the observation period corresponds to oligotrophic type, and only of two lakes - to mesotrophic. Water quality in the nine of the eighteen lakes is considered as mesosaprobic, the other nine - as oligosaprobic.

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

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INTRODUCTION

This report presents qualitative and quantitative indicators of the planktonic algae - phytoplankton, as well as evaluation of the current ecological status of water by the parameters phytoplankton of several thermokarst lakes of the 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. Currently, these water bodies have been poorly studied. We conducted the hydrobiological studies of these lakes for the first time ever. To date, the results of a number of conducted paleogeographic studies of the lakes in Yakutia [1-10] have been published, however, there is very little information on the current state of these lakes. The developmet process of the permafrost lake landscapes containing in their sediments a detailed information about the climate, landscape and hydrology in the Pleistocene and Holocene cannot be studied without the purposeful research of the current state of aquatic organisms. Studying the ecology of aquatic organisms in modern and ancient water bodies makes it possible not only to trace their succession, but also to identify the features and patterns of changes in their structure and productivity in a changing environment. Changes in lake ecosystems affect primaraly the composition of algocenoses. The obtained results can be applied in the geo-environmental monitoring of lakes and the environmental activities in the Krasnoyarsk region, Russia.

MATERIAL AND RESEARCH METHODS

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 Krasnoyarsk region 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. Coordinates of the studied lakes are shown in Fig. 1 and Table 1. (the clearest figure to be left)

Fig. 1. Location map of phytoplankton research area 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

The study area lies entirely in the permafrost area [1]. 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.

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. These data were published in previous reports [11]. There was recorded the presence of higher aquatic vegetation, the size and depth of the studied water body. 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 is close to saturation or greater than its threshold. The water temperature in the lakes varies 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. Such lakes are characterized by very low mineralization (33.2-80 mg/L), dominance of sodium cations, calcium ions, and chloride anions.

During the study period, total 36 quantitative and qualitative samples of planktonic algae were collected. Selection and office processing of 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.

To characterize the structural indicators of phytoplankton communities we studied the relative species diversity (the proportion of a certain taxonomic group of algae in the phytoplankton). Species with abundance or biomass greater or equal to 10% of total rate were dominant in the communities, and 5-10% were subdominant.

We calculated trophic index (ITS) according to the Milius block for each sample: $b=44.87+23.22*\log B$ [14]. To determine the saprobity of the water bodies, the Pantle–Buck saprobity index modified by Sladecek was calculated [15]. We also conducted a descriptive statistical processing of data, and calculated the coefficients of Spierman correlation between the indicators of phytoplankton and hydro-chemical and morphometric parameters of the studied water bodies.

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RESULTS AND DISCUSSIONS

During the observation period, we found 164 planktonic 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 (Table 2, Fig. 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%.

Table 2. Main systematic algae groups of phytoplankton of the lakes in the Khatanga river basin

Phylum	Class	Order
Cyanophyta	*Cyanophyceae*	*Chroococcales*
		Oscillatoriales
		Nostocales
Dinophyta	*Dinophyceae*	*Gymnodiniales*
		Peridiniales
		Gonyaulacales
Chrysophyta	*Chrysophyceae*	*Chromulinales*
	Synurophyceae	*Synurales*
Bacillariophyta	*Coscinodiscophyceae*	*Thalassiosirales*
		Melosirales
		Aulacoseirales
	Bacillariophyceae	*Fragilariales*
		Tabellariales
		Naviculales
		Achnanthales
		Eunotiales
		Cymbellales
		Thalassiophysales
		Rhopalodiales
		Bacillariales
		Surirellales
Euglenophyta	*Euglenophyceae*	*Euglenonales*
Chlorophyta	*Chlorophyceae*	*Volvocales*
		Chlorococcales
	Trebouxiophyceae	*Trebouxiales*
		Oocystales
	Zygnematophyceae	*Zygnematales*

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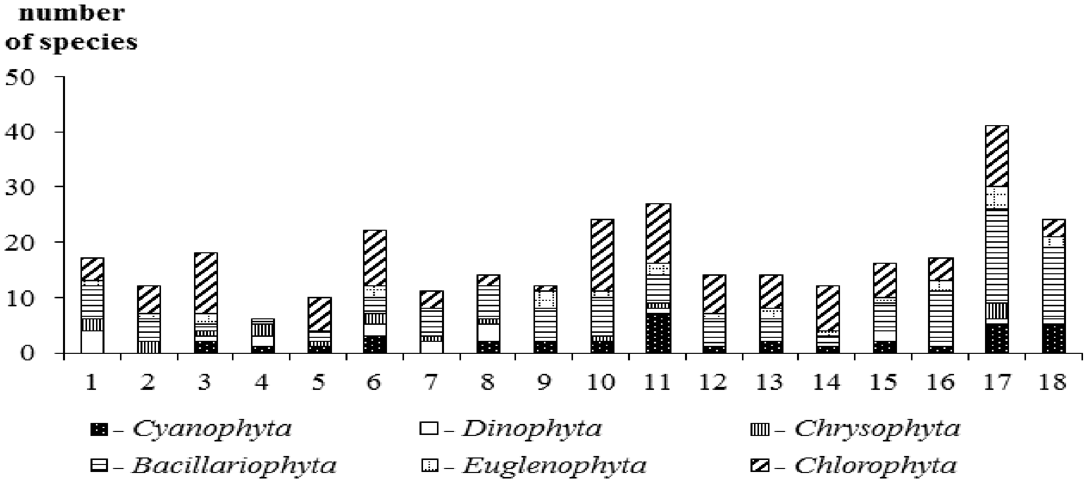

Fig. 2. Distribution of phytoplankton taxa of the lakes in the Khatanga river basin (2013): the Y-axis indicates the numbers of the studied water bodies

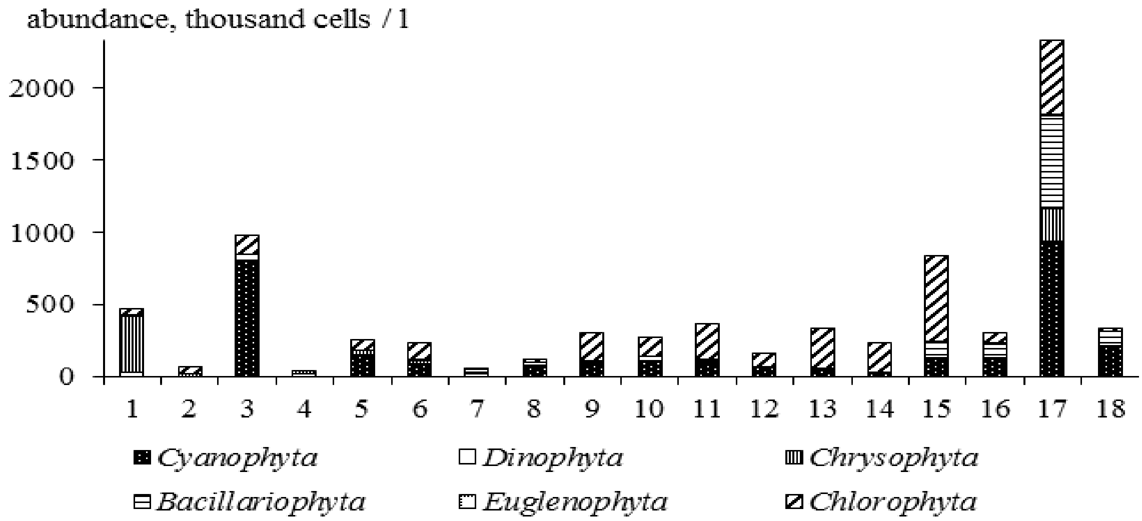

Fig. 3. Abundance (thous. cl./l) of individual systematic groups of phytoplankton of the lakes in the Khatanga river basin (2013): the X-axis indicates the numbers of the studied water bodies

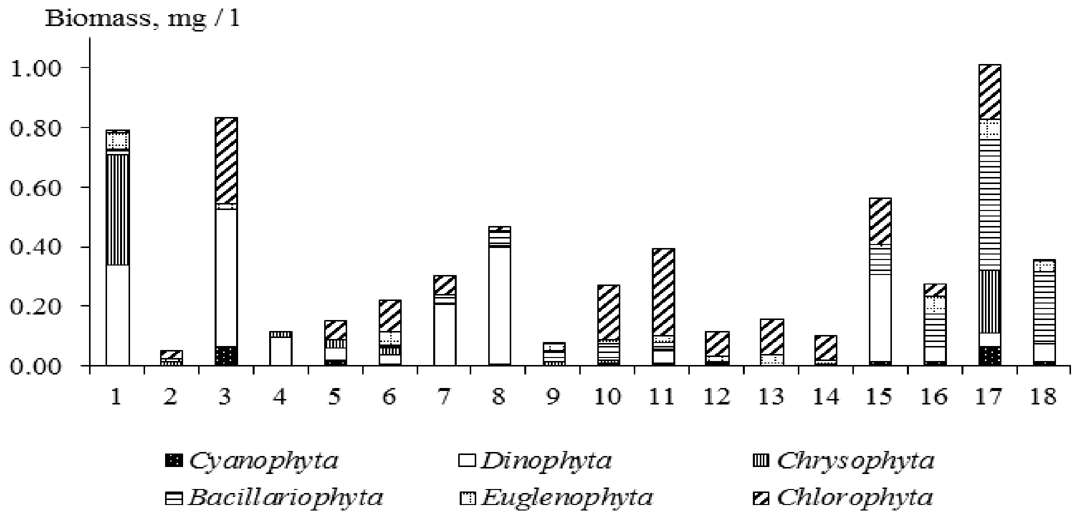

Fig. 4. Biomass (mg/l) of individual systematic groups of phytoplankton of the lakes in the Khatanga river basin (2013): the X-axis indicates the numbers of the studied water bodies.

Quantitative indicators of the phytoplankton of the studied lakes are low, the total abundance and biomass of phytoplankton varies from 31.50-2,331.50 thousand Cl./L and 0.05-1.01 mg/L (Figure 3, 4). Quantitavely, the studied lakes differ greatly in dominant species of phytoplankton (Table 3). The most prevalent in number are green-blue algae, and in biomass - dinoflagellate, green and golden algae. Contrary to our expectations, the diatoms did not grow too massively during these studies. In most of the water bodies, their abundance and biomass was low, only lakes number 17 and 18 had diatoms 30.1-32.5% of the total abundance, and 54.8-67.5% of the total biomass. Despite the high species diversity, the frequency of occurrence and abundance of diatom species was low in most water bodies. By the composition and nature of ecological groups of algae, the diatom flora is defined as freshwater, typical of cold and clean, quite deep water bodies with a developed littoral zone and a neutral and (or) slightly alkaline medium.

Table 3. Dominating associations of planktonic algae of the lakes in the Khatanga river basin (2013)

Lake No.	Dominant species
1	*Peridinium bipes* Stein., *Peridinium palatinum* Lauter., *Dinobryon divergens* Imhof., *Trachelomonas intermedia* Dang.
2	*Dinobryon divergens* Imhof., *Stephanodiscus hantzschii* Crun., *Trachelomonas planctonica* Swir.
3	*Aphanizomenon flos-aquae* (l.) Ralfs., *Peridinium aciculiferum* Lemm., *Peridinium bipes* Stein., *Chlamydomonas* sp., *Pandorina morum* (Mill.) Bory., *Dictyosphaerium pulchellum* Wood., *Cosmarium blyttii* Will.
4	*Peridinium aciculiferum* Lemm., *Peridinium bipes* Stein., *Dinobryon divergens* Imhof., *Euastrum elegans* (Bréb.) Kütz. ex Ralfs.
5	*Dinobryon divergens* Imhof., *Dictyosphaerium pulchellum* Wood.
6	*Anabaena scheremetievi* Elenc., *Aphanizomenon flos-aquae* (l.) Ralfs., *Trachelomonas intermedia* Dang., *Asterococcus superbus* (Cienk.) Scherff., *Pandorina morum* (Mill.) Bory., *Pediastrum boryanum* (Turp.) Menegh., *Coelastrum proboscideum* Bohl., *Botryococcus* Kütz., *Gloeocapsa limnetica* (Lemm.)Hollerb., *Cocconeis placentula* Ehr., *Chromulina* sp., *Dinobryon divergens* Imhof.
7	*Peridinium bipes* Stein., *Ceratium hirundinella* (O.P.M.) Schrank., *Dinobryon divergens* Imhof., *Asterionella formosa* Hass., *Pinnularia borealis* Ehr.
8	*Anabaena scheremetievi* Elenc., *Dinobryon divergens* Imhof., *Ceratium hirundinella* (O.P.M.) Schrank., *Peridinium aciculiferum* Lemm., *Anabaena scheremetievi* Elenc., *Cyclotella meneghiniana* Kiitz., *Pinnularia borealis* Ehr., *Eunotia tenella* (Grunow) Hust. in A. Sch., *Oocystis natans* Wille.
9	*Oscillatoria planctonica* Wotosz., *Anabaena scheremetievi* Elenc., *Dinobryon divergens* Imhof., *Synedra ulna* (Nitzsch.) Ehr., *Trachelomonas intermedia* Dang., *Trachelomonas planctonica* Swir., *Botryococcus* Kütz.
10	*Anabaena scheremetievi* Elenc., *Aphanizomenon flos-aquae (*l.) Ralfs., *Dinobryon divergens* Imhof., *Dictyosphaerium pulchellum* Wood., *Scenedesmus naegelii* Breb., *Crucigenia rectangularis* (A..Br.) Gay., *Euastrum elegans* (Bréb.) Kütz. ex Ralfs., *Cosmarium margaritiferum* Menegh., *Cosmarium humile (*Gay.) Nordst. , *Staurastrum brachiatum* Ralfs., *Staurastrum setigerum* Cleve., *Campylodiscus hibernicus* Ehr.
11	*Chroococcus turgidus* (Kütz.) Nägeli., *Gloeocapsa limnetica* (Lemm.)Hollerb., *Gloeocapsa turgida* (Kiitz.) Hollerb. Emend., *Gomphosphaeria lacustris* Chod., *Anabaena scheremetievi* Elenc., *Peridinium palatinum* Lauter., *Dinobryon divergens* Imhof., *Diatoma vulgare* Bory., *Trachelomonas planctonica* Swir., *Chlamydomonas* sp., *Pandorina morum* (Mill.) Bory., *Pediastrum boryanum (*Turp.) Menegh., *Dictyosphaerium* sp., *Scenedesmus naegelii* Breb., *Cosmarium blyttii* Will.
12	*Gloeocapsa minor* (Kiitz.) Hollerb. ampl., *Anabaena scheremetievi* Elenc., *Aulacoseira italica* (Kiitz.) Sim., *Synedra ulna* (Nitzsch.) Ehr., *Coenococcus planktonicus* Korschik., *Oocystis natans* Wille.
13	*Gloeocapsa minor* (Kiitz.) Hollerb. ampl., *Anabaena scheremetievi* Elenc., *Aulacoseira italica* (Kiitz.) Sim., *Synedra ulna* (Nitzsch.) Ehr., *Coenococcus planktonicus* Korschik., *Oocystis natans* Wille.
14	*Anabaena scheremetievi* Elenc., *Pinnularia borealis* Ehr., *Trachelomonas planctonica* Swir., *Scenedesmus guadricauda* (Turp.) Breb., *Crucigenia tetrapedia* (Kirchn.) .et.W., *Oocystis natans* Wille.
15	*Gomphosphaeria lacustris* Chod., *Anabaena scheremetievi* Elenc., *Peridinium aciculiferum* Lemm., *Peridinium bipes* Stein., *Asterionella formosa* Hass., *Pediastrum boryanum* (Turp.) Menegh., *Pediastrum duplex* Meyen., *Dictyosphaerium pulchellum* Wood., *Staurastrum gracil* Ralfs., *Spondylosium planum* (Wolle) West & G.S.West.
16	*Anabaena scheremetievi* Elenc., *Peridinium palatinum* Lauter., *Asterionella formosa* Hass., *Nitzschia sigmoidea* (Nitzsch.) W.Sm., *Nitzschia vermicularis* (Kiitz.) Grun., *Trachelomonas intermedia* Dang., *Trachelomonas planctonica* Swir., *Pediastrum boryanum* (Turp.) Menegh., *Oocystis natans* Wille.
17	*Gomphosphaeria lacustris* Chod., *Oscillatoria* sp., *Anabaena flos-aquae* Breb., *Aphanizomenon flos-aquae* (l.) Ralfs., *Dinobryon divergens* Imhof., *Pseudokephyrion* sp., *Aulacoseira islandica* (O. Mull.) Sim., *Aulacoseira italica* (Kiitz.) Sim., *Asterionella formosa* Hass., *Tabellaria fenestrata* (Lyngb.) Kiitz., *Pediastrum boryanum* (Turp.) Menegh., *Tetrastrum alpinum* Korschik., *Crucigenia tetrapedia* (Kirchn.) W.et.W.
18	*Gomphosphaeria lacustris* Chod., *Anabaena flos-aquae* Breb., *Aphanizomenon flos-aquae* (l.) Ralfs., *Peridinium aciculiferum* Lemm., *Fragilaria construens* (Ehr.) Grun., *Synedra ulna* (Nitzsch.) Ehr., *Diatoma elongatum* (Lyngb.) Ag. var. *Elongatum, Tabellaria fenestrata* (Lyngb.) Kiitz., *Tabellaria fllocculosa* (Roth.) Kutz.

Indicators of quantitative development of phytoplankton are widely used to characterize the state and trophic status of water bodies. Trophic indices calculated according to the Milius block [14] to assess the trophic status of water bodies have characterized these water bodies in the study period mostly as oligotrophic (11.7-39.1), and the lakes №3 and №17 as mesotrophic (43.0-43.6) (Fig. 5). According to the caltulations of the Sladecek-modified Pantle–Buck saprobity indices (*S*, *P/B*) by phytoplankton biomass, the quality in the nine of the eighteen lakes is considered as mesosaprobic (1.56-1.92), the other nine - as oligosaprobic (0.17-1.50) (Fig. 6).

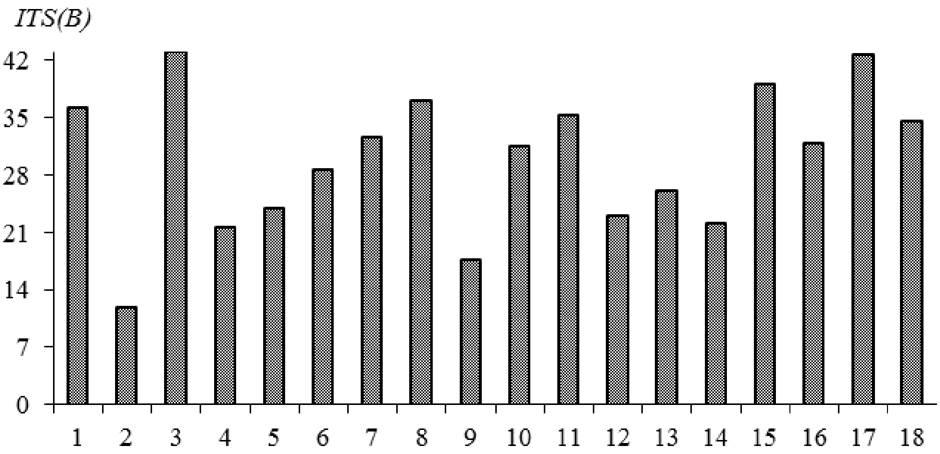

Fig. 5. Trophic index (ITS) of the lakes in the Khatanga river basin (2013) by phytoplankton biomass: the X-axis indicates the numbers of the studied water bodies

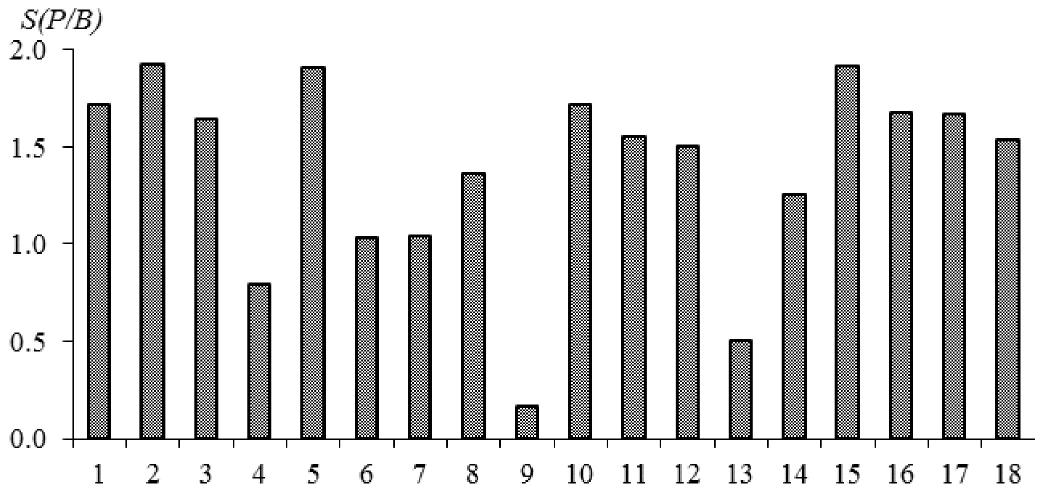

Fig. 6. Saprobic index (S(P/B) of the lakes in the Khatanga river basin (2013) by phytoplankton indicators: the X-axis indicates the numbers of the studied water bodies

SUMMARY

During the study, the coefficients of Spierman correlation between the indicators of phytoplankton and hydro-chemical and morphometric parameters of the lakes in the Khatanga river basin were calculated, and some relations were found. A negative correlation (r=-0.5- -0.6 at p<0.05) is observed between the content of green and euglena algae in the water and the depth of water bodies. Dinoflagellates, found in these water bodies, prefer lower water temperature (r= *-0.5* at p<0.05). We also observed an increase in the concentration of golden algae at higher alkalinity (r= *0.5* at p<0.05), although no direct relation to pH values was found. According to the literature, the majority of golden algae is mainly found in freshwater basins of the temperate climate, reaching the highest species diversity in the acidic waters of sphagnum bogs, which is associated with the formation of acidic, rather than alkaline phosphatases. Golden algae reach their maximum during the cold season: they dominate in the plankton in early spring, late fall and winter [16]. Further and complete explanation of the observed phenomena requires additional research and investigation of the seasonal dynamics of the algae development in the studied water bodies.

CONCLUSION

The obtained results can be also applied in the development of predictive models of northern region 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.

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REFERENCES

[1] Gorodnichev R.M. The modern Russian-German project for study of the water bodies of northern ecosystems (by the example of the Khatanga river basin) / R.M. Gorodnichev, A.I. Kolmogorov, L.A. Pestryakova // Earth Sciences: Sustainable Territory Development - theory and practice. Cheboksary: Publishing House of the Chuvash University, 2012. Pp. 34-35.
[2] Frolova L., Nazarova L., Pestryakova L., Herzschuh U. Subfossil cladoceran remains from sediment in thermokarst lakes in northeastern Siberia, Russia. // Journal of Paleolimnology. 2014. Volume 52, Issue 1. Pp. 107-119.
[3] Frolova L.A., L.B. Nazarova, L.A. Pestryakova, U. Herzschuh. Analysis of the effects of climate-dependent factors on the formation of zooplankton communities that inhabit Arctic lakes in the Anabar river basin //Contemparary Problems of Ecology, 2013.Volume 6, No 1, Pp. 1-11.
[4] Kienast, F. Paleontological records prove boreal woodland under dry inland climate at today's Arctic coast in Beringia during the last interglacial / F.Kienast, S.Wetterich, S.Kuzmina, L.Schirrmeister, A.Andreev, P.Tarasov, L. Nazarova, A.Kossler, L. Frolova, V.Kunitsky //Quaternary Science Reviews. 2011. 30. 17/18. P. 2134-2159.
[5] Kopyrina L.I. Algae of the water bodies of Verkhoyansk Range (Yakutia) // Algology. 2012. V. 22. No.4. Pp. 382-390.
[6] Methodical approaches to the use of biological indicators in paleoecology / Ed. L.B. Nazarov. Kazan: Publishing House of Kazan University, 2011. P. 280.
[7] Pestryakova L.A. Diatom assemblages of Yakutian lakes. Yakutsk: YSU Publishing House, 2008. P. 177.
[8] Remigailo P.A. Systematic structure of phytoplankton of the major rivers of Central Yakutia floristic region // Flora of Asian Russia. 2011 a. No.2 (8). Pp. 20-27.
[9] Remigailo P.A. The taxonomic structure of algal flora of the Viliui river in the natural flow and under regulated regime // Science and education. 2011 b. No.3. Pp. 25-29.
[10] Spiridonova I.M. Diatoms of the polygonal tundra habitats in the Khatanga river basin / I.M. Spiridonova, L.A. Pestriakova, R. Cybulski, W. Hertsshu // Ecological problems of northern regions and their solutions: Proceedings of IV scientific conference with the international participation of the Institute of North industrial ecology problems KSC RAS, Apatity, April 12-13, 2012. Pp. 122-126.
[11] Katharina Dulias, Katharina Dulias, Kathleen Rosmarie Stoof-Leichsenring, Luidmila A. Pestryakova, Ulrike Herzschuh. Sedimentary DNA versus morphology in the analysis of diatom-environmental relationships // Journal of Paleolimnology. 2016 (in press).
[12] The methodology of studying biogeocoenosis of inland waters / Ed. in Chief F.D. Mordukhai-Boltovskoi. - M.: Nauka, 1975 - P. 240.
[13] Algae. Reference book / S.P. Wasser, N.V. Kondratiev. Kyiv: Naukova Dumka, 1989. P. 608.
[14] Andronikova I.N. Classification of lakes by the level of biological productivity // Theoretical problems of lake classification. - St.P.: "Nauka", 1993. - Pp. 51-72.
[15] Sladecek V. System of water quality from the biological point of view. // Arch. Hydrobiol., Beihefz., Ergebnisse der Limnol. 1973. Bd 7. P. 189.
[16] Matvienko A.M. Chrystophyte algae // USSR freshwater algae indicator. M., 1954. Vol.3. P. 188.