Phytoplankton of water bodies in the area of the planned oil pipeline (Russia, Yakutia)*

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ABSTRACT

In plankton of 12 water bodies of the Middle Lena, located in the area of the planned oil pipeline, referring to the East Siberia – Pacific Ocean system, 125 species of algae were found. From a floristic and ecological-geographical standpoint, phytoplankton is peculiar to algal communities of northern water bodies. According to the quantitative development of phytoplankton, the water bodies are characterized as oligotrophic. Peculiarities of the composition and distribution of phytoplankton in the studied water bodies are revealed depending on their hydrological and geographical conditions. The data obtained serve as the basis for creating the monitoring base under intensifying conditions of the technogenic influence on water ecosystems of the Middle Lena basin.

KEYWORDS: phytoplankton, rivers, thermokarst lakes, the Middle Lena basin.

INTRODUCTION

Currently, the algae of small and middle tributaries of the Lena have not been adequately investigated. The plankton communities of algae from 12 water bodies of the Middle Lena basin were studied to estimate the influence on the environment of the construction and exploitation of the oil pipeline referring to the East Siberia – Pacific Ocean system (ESPO). The water bodies included: the Lena and its nine tributaries of the first and second orders flowing along the Lena-Vilyuisk and Lena-Aldansk interfluve and also two lakes of the thermokarst origin, which are located near the planned oil pipeline in the Lena-Vilyuisk interfluve. There are data from literature on algae only from some of these water bodies: the

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Middle Lena, the Amge and Tuolbe Rivers (Komarenko, 1956; Vasil'yeva et al., 1984, 2001; Rozhkova et al., 1997; Vasil'yeva & Pshennikova, 2000). According to the project, the planned oil pipeline will cross the mentioned water bodies worsening the ecological situation.

The main goal of the work is to study the characteristic features of the composition and distribution of phytoplankton in water bodies near zones of the planned oil pipeline of the ESPO system, to create a basis for biomonitoring under conditions of the expected intensification of the technogenic influence on the water ecosystems of the Middle Lena basin.

MATERIALS AND METHODS

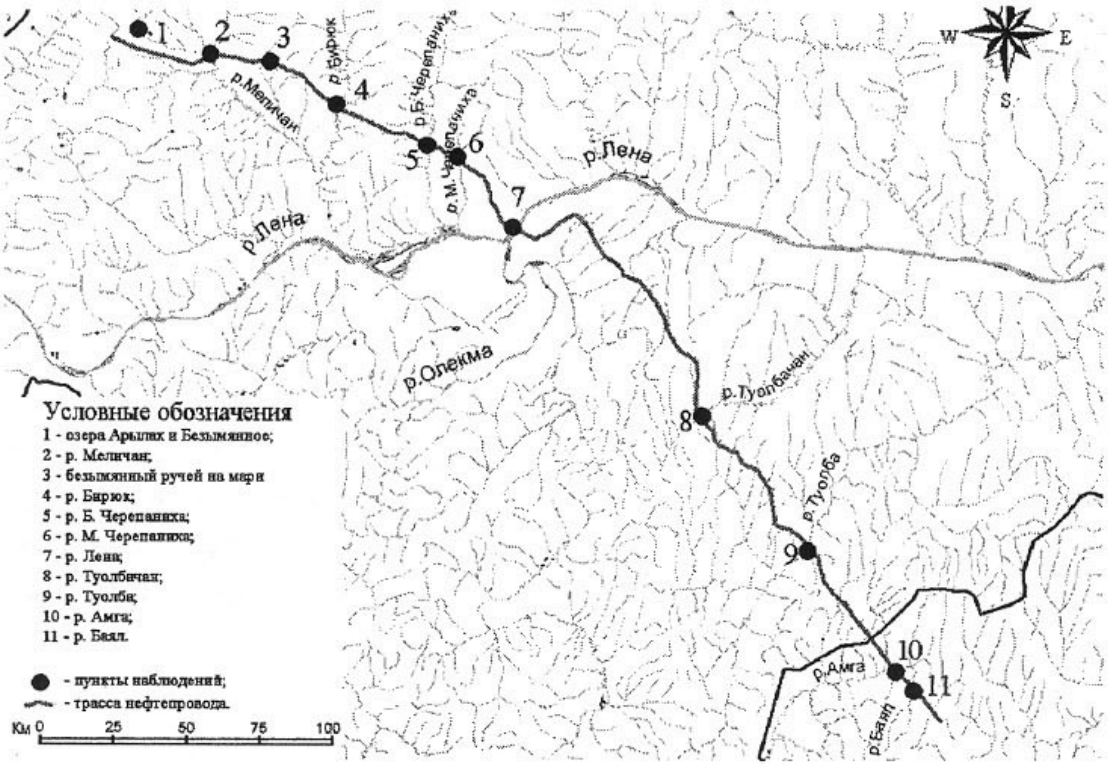
The phytoplankton samples collected in 2006 in water bodies near the area of the planned oil pipeline were studied (schematic map). The samples were taken from littoral and pelagial areas of the water bodies' superficial water horizons of water (0-0.3 m). The samples for the analysis of the qualitative composition of phytoplankton were taken by the Apshtein net (sieve N 75). The quantitative water samples of volume (1.5 L) were concentrated using the Sartorius membrane filters (pore diameter 2.5 μm). The specimens were fixed with 4% formaldehyde solution. In all, 110 plankton specimens were gathered and treated. The microscope preparation was performed by an Olympus BH-2 and also using the procedures and determinants generally accepted in algology.

The taxonomic structure of phytoplankton was analyzed by standard methods accepted in comparative floristics (Schmidt, 1984). The indices of taxonomic diversity or "flora proportions" are given accordingly: a relative number of families, taken as 1; the average mean number of genera in the family (g/f); the average number of species in the family (s/f); the average number of intraspecific taxa (including nomenclature type of the species) in the family (is/f). The coefficient of the generic saturation with species is derived from the ratio of total number of genera to total number of species, the species variability – the ratio of intraspecific taxa to species.

RESULTS AND DISCUSSION

In the plankton of water bodies located in the area of the planned oil pipeline we revealed 125 species of algae (130 taxa lowered by the rank of the genus, including the nomenclature type of the species) from 5 divisions, classes, 13 orders, 37 families, and 59 genera (Table 1).

The diatomic, green and blue-green algae, typical of the water bodies of the North, provide the basis for phytoplankton (94.4%) (Getsen, 1985; Vasil'yeva, 1989; Yermolayev et al., 2003).



Schematic map

Map symbols: 1 – the Arylak and Bezymyannoye lakes, 2 – the Melichan River, 3 – the Nameless stream on mari, 4 – the Biryuk River, 5 – the Great Cherepanikha River, 6 – the Small Cherepanikha River, 7 – the Lena River, 8 – the Toulbachan River, 9 – the Tuolba River, 10 – the Amga River, 11 – the Bayal River. ● – Base stations, —— – The oil pipeline route from 1 to 11.

Here at the level of classes there are *Pennatophyceae* (42.1% of species composition), *Chlorophyceae* (24.6%), and *Conjugatophyceae* (10.3%); at the level of orders – *Raphales* (30.2%) and *Chlorococcales* (23.0%). Ten families of algae, the largest in quantity of species, include 73 species of algae (58.2% of total number of species), which refer to the diatomic, green and blue-green algae. A high percentage of species in the composition of leading families is a characteristic feature of algoflora of the northern regions, and of Yakutia in particular (Vasil'yeva et al., 2005). The first three positions belong to families *Fragilariaceae* (8.7% of species composition), *Desmidiaceae* (7.1%), and *Scenedesmaceae* (5.6%). There are 14 families of one species, almost one third of all families. An increase in the number of families with one representative of the flora is peculiar to the northern flora (Getsen, 1985). One- and two-species genera make up 78.3% of the generic list. Predominance of the genera with a small number of species is also typical of the northern flora. The analysis of the generic range of algae from the studied water bodies indicates the uneven distribution of species by genera. Twelve leading genera, comprising about 20% of all generic composition, envelope 53% of the total number of species. The floral proportions are 1:1.6:3.3:3.4. The generic saturation is 2.1. Variability of the species is 1.0.

TABLE 1. Systematic composition of phytoplankton from water bodies of the area of the planned oil pipeline

Division	Number						%
	Classes	Orders	Families	Genera	Species	Species and varieties	Total number of species (125)
Cyanophyta	2	4	6	8	15	15	12.0
Chrysophyta	1	1	2	3	5	5	4.0
Bacillariophyta	2	4	15	23	59	64	472
Xanthophyta	1	1	1	1	2	2	1.6
Chlorophyta	2	3	14	25	44	44	35.2
Total	8	13	38	60	125	130	100

According to classification by Alekhin (1970) the studied water bodies are little- and medium-mineralized; the total quantity of dissolved substances varies from 94.0 to 427.6 mg/L; that results in the predominance of oligohalobs in the phytoplankton (44.6% of the species composition). The value of pH varies from 6.19 to 8. 25, therefore, there is a significant share of indifferents (23.1% of the species composition) and alkaliphiles (14.6 %). According to the geographic attribution, the phytoplankton cosmopolitans and boreal species (36.2%) form the basis of phytoplankton; a share of arcto-alpine species is small – 9.2%. Severe climatic conditions explain the presence in plankton of stenothermal, cold-loving, diatom algae – *Hannaea arcus* (Ehr.) Patr., *H. arcus* var. *linearis* (Holmboe) Patr. As to the concentration of organic substances in the water layer, the composition of algae-indicators of saprobility is filled by 49% with β-mesosaprobic forms, by 23.6% – with species developing in the transition zone between β-meso- and oligosaprobic ones. There are 11.8% of algae characterizing waters with high indices of saprobility (α and ρ-α) and 15.7% with low indices of saprobility (χ, χ-o, o-χ).

The Lena River. The transfer point of oil pipeline via the Lena River is situated 2,100 km from the river mouth. The catchment area of the Lena in this site is 560,000 km^2. As to species composition, the Lena phytoplankton is the most diverse; among the other studied water bodies 51 species and a variety of algae from three divisions were revealed. The diatom algae are the basic part of phytoplankton; their share makes up from 86.6% to 95.9% of total algal biomass. The percentage of green algae in samples is from 0.3% to 7.2%, of yellow-green – from 0.6% to 6.2% of the phytoplankton biomass. A set of dominants and the level of development of algal communities in the hydrobiological section of the river are different. The river in the sampling site has a length of 1,350 m, single bed – without islands and channels, the banks consist of cobble round-stones, the current along the fairway – 1.7 m/s. Upstream in the left bank (15 km) there is the town of Olekminsk, downstream from it up to the oil pipeline transition small villages are situated. Under these conditions the left bank and fairway phytoplankton are subjected to anthropogenic influence. For instance, the content of ammonia nitrogen in the left bank and fairway is 0.44 mg/L and exceeds the maximum permissible concentration (MPC) by fishery norms. The latter is expressed in a higher level of phytoplankton development in the left bank and fairway (Table 2).

TABLE 2. Number (*N*, thousandths of cells/L) and biomass (*B*, mg/L) of phytoplankton of the Lena River in the hydrobiological section in the transition point of the planned oil pipeline

Locality of phytoplankton	*Bacillariophyta*		*Chlorophyta*		*Chrysophyta*		Total	
	N	*B*	*N*	*B*	*N*	*B*	*N*	*B*
Left bank	894.4	0.4070	343.2	0.0339	52.0	0.0290	1289.6	0.4699
Fairway	728.0	0.4358	624.0	0.0467	20.8	0.0029	1372.8	0.4854
Right bank	32.9	0.0355	3.5	0.0001	3.5	0.0014	39.9	0.0370

The following algal species were predominated by biomass in the left bank: *Nitzschia macilenta* Greg., *N. acicularis* W. Sm., *Synedra ulna* (Nitzsch) Ehr., *Cyclotella kuetzingiana* Thw., and *Dinobryon divergens* Imhof, a representative of yellow-green algae. The characteristic peculiarity for this zone is the presence among dominants of forms with high saprobic index. Along the fairway such species as *Tabellaria fenestrata* (Lyngb.) Kütz. var. *intermedia* Grun., and *Gomphonema ventricosum* Greg. predominated, but here the species *S. ulna* and *N. acicularis*, with high saprobility index, form the basic part. As a result, the saprobility indices for the left-bank and fairway are high – 2.20 and 2.19, which corresponds to β-α-mesosaprobic pollution zone.

In the right-bank flow the indices of phytoplankton biomass are lower, to a certain extent (Table 2); the dominating species include *Navicula bacillum* Ehr., *S. ulna*, *Tabellaria fenestrata* var. *intermedia*, and *Fragilaria virescens* Ralfs. The content of ammonia nitrogen in the right bank does not exceed the fishery (MPC). The left-bank and fairway phytoplankton are characterized by abundant development of *N. acicularis*, which amounted to 30.7% and 25.8% of the total quantity, respectively, in the right bank – 4.4%. The saprobility index of the right bank is 1.40. According to the data available in literature on the state of the Lena river at the beginning of the 1980s (Vasil'yeva et al., 1984), the saprobility index of the river in the region of the town of Olekminsk did not exceed 1.60, and *N. acicularis* was not found among the dominants.

The level of species diversity according to Shennon-Wiver index (Hb) is high: in the left bank – 3.04, along the fairway – 3.81, in the right bank – 3.66.

The Amga River – is the right tributary of the Lena River of the second order; the length of the river is 1462 km, the basin area 69, 300 km^2, banks and bottom consist of pebbles, the flow rate – 0.9 m/s. Phytoplankton is represented by 30 species and varieties from three divisions. The diatoms are dominating species (Table 3) – 77.9% of total biomass, 20.2% – green and 1.9% yellow-green. The species dominating in plankton were – *Cymbella tumida* (Bréb.) V.H., *Achnanthes giberrula* Grun., *Nitzschia sublinearis* Hust.,

Synedra tabulata (Ag.) Kütz., and *S. ulna*. Among dominants, the benthic forms prevail. They are delivered into plankton from overgrowths under conditions of lotic water body with small depths (up to 1 m on rifts and up to 2 m on reaches). The index of saprobility is 1.90. The index of species diversity Hb is high for the river plankton and varies in sampling points from 3.00 to 3.28.

The Tuolba River is the right tributary of the Lena: its length – 395 km, the catchment area – 15, 800 km^2, banks and bottom are pebble, the flow rate – 1.9 m/s. In the plankton 20 species and forms of algae are revealed. The basic part of the plankton biomass of the river consists of diatoms (Table 3) – 90.3%, green – 9.4%, and yellow-green – 0.3%. The main structure-forming species are *Synedra ulna*, *Diatoma elongatum* (Lyngb.) Ag. var. *tenue* (Ag.) V.H., and *Cymbella ventricosa* Kütz. The saprobility index is 1.89. The species diversity index Hb is lowered and varies from 1.96 to 2.52.

The Biryuk River is the left tributary of the Lena; its length is 267 km, the catchment area – 9, 700 km^2, the flow rate – 1 m/s, the beaches are sandy-silty. In the plankton 19 species and forms of algae were observed. The basic part of biomass from the plankton algal groupings consists of diatoms (88.9% of the total phytoplankton biomass), the contribution of green algae is considerably lower (11.1%) (Table 3). The dominating species in the Biryuk River plankton are *Diatomeae* and *Desmidiales: Aulacosira granulata* (Ehr.) Simon. (in one of the specimens it makes up 29.9% of the total phytoplankton biomass), *Synedra ulna*, *Cosmarium sphagnicolum* W. et G.S. West. Due to the abundant development of the same species the index of biodiversity is lowered and varies within 1.68-2.15. The saprobility index is 1.79.

TABLE 3. Indices of the quantitative development of phytoplankton from the studied water bodies in the planned oil pipeline area

Water body	*Bacillario-phyta*	*Chloro-phyta*	*Chrysso-phyta*	*Cyano-phyta*	*Xantho-phyta*	Total
The Amga River	23.05 0.0166	3.99 0.0043	0.78 0.0004	-	-	27.82 0.0213
The Tuolba River	35.07 0.0307	1.04 0.0032	-	-	0.52 0.0001	36.63 0.340
The Biryuk River	1.02 0.0008	0.48 0.0001	-	-	-	1.50 0.0009
The Melichan River	0.28 0.0018	0.13 0.00001	-	218.38 0.0083	-	218.79 0.01011
The Tuolbachan River	0.66 0.0034	0.52 0.0019	0.11 0.00001	-	-	1.29 0.00531

The Great Cherepanikha River	0.57 0.0020	0.10 0.0005	0.05 0.00001	-	-	0.72 0.00251
The Small Cherepanikha	0.53 0.0005	0.36 0.0001	-	-	-	0.89 0.0006
The Bayal River	1.0 0.0033	0.73 0.0014	-	10.51 0.00004	-	13.04 0.00474
The Nameless stream on mari	0.47 0.0012	-	-	-	0.05 0.00003	0.52 0.00123
Arylakh Lake	-	2.34 0,0020	-	1303.65 0,2222	-	1305.99 0,2242
Nameless Lake	1.17 0.0009	2.34 0.0012	-	348.27 0.0027	-	351.78 0.0048

Note. Above the line– number, thousand of cell/L, under the line – biomass, mg/L.

The Melichan River is the left tributary of the Lena River of the second order; it flows along the swamped peat bogs of the Lena-Vilyuisk interfluve, the length of the river – 144 km, the basin area – 4, 900 km^2, and the flow rate – 0.6 m/s. We found five algal species in samples. One species, *Aphanizomenon flos-aquae* (L.) Ralfs, a representative of blue-green algae, predominates in the river plankton. Its biomass in samples is from 49.5% to 100% of the total phytoplankton biomass. The Melichan River is the only one among the studied rivers where the content of mineral phosphorus is characterized by a hundredth part of mg of P/L, which promotes the development of algae. In other rivers phosphorus is either absent or is a 0.001 part of mg of P/L. The diversity index is very low – from 0.01 to 1.00. The saprobility level is 1.70.

The Tuolbachan River is the right tributary of the Lena; its length is 185 км, the catchment area – 3, 900 km^2, beaches and bottom are pebble, and the flow rate – 0.9 m/s. The algal communities of plankton are represented by 29 species and varieties, among which the basic part of phytoplankton belongs to diatomic algae (64.0%), a share of green algae is significant (35.8%), and that of yellow-green – insignificant 0.2% (Table 3.) The structure-forming species are representatives of *Bacillariophyta* and *Desmidiales*: *Cymbella lanceolata* (Ehr.) V.H., *Cosmarium amphichondrum* Skuja, *Nitzschia macilenta*, *Cosmoastrum punctulatum* (Bréb.) Pal.-Mordv., and *Tabellaria fenestrata*. The saprobility index is 1.52. The biodiversity index is high for the river plankton and varies between 2.53-3.50.

The Great Cherepanikha River is the left tributary of the Lena River; its length is 125 km, the catchment area – 1, 800 км^2, the flow rate – 0.8 m/s, and the bottom and beaches are pebble. In the plankton 14 species and forms of algae are detected. A portion of diatoms makes up 79.7% of phytoplankton biomass, green algae amount to 19.9%, and contribution of yellow-green algae is insignificant (Table 3). In the composition of the

dominating complex of species there are diatomic algae: *Synedra ulna, Melosira varians* Ag., and *Nitzschia filiformis* (W. Sm.) Hust. The index of biodiversity is low – 1.98. The saprobic index is 1.83.

The Small Cherepanikha River is the left tributary of the Lena; its length is 65 km, the catchment area – 469 km^2, the flow rate - 0.6 m/s, and the bottom and beaches are sand-silty. Phytoplankton includes 13 species and forms. The diatomic algae in the composition of phytoplankton account for 83.3% of biomass, the green ones – 16.7% (Table 3). Diatoms *Synedra ulna, Melosira varians*, and *Nitzschia filiformis* predominate. The saprobility index of water flow is slightly high – 2.26. The biodiversity index for the river plankton is high at 2.77.

The Bayal River is a small water flow of 40 km in length and represents the right tributary of the Lena of the second order; the flow rate – 0.6 m/s and beaches are sandy-pebble. The river phytoplankton is represented by 23 species with varieties of algae. Its biomass is mainly represented by diatomic algae (69.6% of the total biomass of plankton) with participation of green algae; a portion of blue-green algae is insignificant (0.8%) (Table 3). In the composition of dominants there are representatives of *Desmidiales, Chlorococcales,* and *Desmidiales: Chlorococcum infusionum* (Schrank) Menegh., *Cosmarium amphichondrum, Trochiscia aciculifera* (Lagerh.) Hansg., *Tabellaria fenestrata*, and *Gomphonema intricatum* Kütz. var. *pumilum* Grun. The saprobility index of water flow is 1.59. The biodiversity index Hb is high and varies in sampling sites within 2.90-3.02.

The Nameless Stream on mari of the Leno-Vilyusk interfluve is a left-bank tributary of the second order; beaches of the stream are sandy-silty. Phytoplankton are represented by nine species and varieties of algae. The basic part of phytoplankton are diatoms (Table 3), a portion of yellow-green is insignificant. The species dominating by biomass are typically rheophilic plankton forms of diatoms: *Tabellaria fenestrata* and *Synedra ulna*. The biodiversity index is 2.48. The saprobility index is 1.18.

The thermokarst lakes are situated on mari of the Leno-Vilyuisk interfluve near the planned oil pipeline route; lake beaches are peaty, the depth is 1.5-2.0 m. Lake Arylakh is of size 2 by 3 km. Phytoplankton relative to the species composition is poor and accounts for six species and forms. A representative of blue-green (Table 3) – *Aphanizomenon flos-aquae* – forms the basis of its biomass (99.1% of total biomass). In the lake water it is possible to observe, with the naked eye, green turf particles formed by this alga. However, water bloom did not take place. The index of species diversity of the water body is very low – 0.09. The saprobility index is 1.70.

The Nameless Lake is 1.3×0.8 km. Phytoplankton consists of 14 species and forms of algae. The basic part of plankton consists of blue-green (56.3% of total biomass) and green (25%) algae; the contribution of the diatomic algae is less (18.8%). Among dominants, there are representatives of blue-green algae, desmidiales, and diatoms: *Oscillatoria woronichinii* Anissim., *Cosmarium subarctoum* (Lagerh.) Racib., and *Tabelaria fenestrata*. The total level of plankton development for the lake as a stagnant water body is small (Table 3). The biodiversity index is low – 2.27. The saprobility index is 1.63.

CONCLUSIONS

In the plankton of the studied water bodies we found 125 species from 5 divisions, 8 classes, 13 orders, 37 families, and 59 genera. Representatives of diatomic (47.2% of total number of species), green (35.2%), and blue-green (12.0%) algae form the basis of the taxonomic range. Relative to the floristic and ecological and geographical aspect, the phytoplankton has the distinguishing features of algal communities of the northern water bodies. As to species richness and quantitative development, the phytoplankton is the most diverse in the rivers with a great catchment area – these are the Lena, Amga, and Tuolb Rivers. The basic part of phytoplankton biomass in a great number of water bodies consists of diatoms (64.8-100% of total biomass), with the participation of green (9.8-35.2%) algae. In the phytoplankton of rivers with the flow rate of more than 1 m/s a share of green algae in the total biomass does not exceed 11.1%; in the formation of algal biomass of plankton of slow-flowing rivers a portion of chlorophytes is high. In water bodies situated in the swamped peat bogs of the Leno-Vilyuisk interfluve (the Melichan River, the thermokarsk lakes), a portion of blue-green algae is higher (56.3-99.1% of total phytoplankton biomass).

The studied aquatories by their species composition and quantitative development of phytoplankton are characterized as the northern oligotrophic water bodies. The data obtained on the plankton communities of algae underlie the creation of the biomonitoring base under conditions of growing technogenic influences on water ecosystems of the Middle Lena basin.

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