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Anthropogenic Transformation of Biocenosis Structural Organization in Lena River Mouth Area

A. M. Nikanorov[a], V. A. Bryzgalo[b], L. S. Kosmenko[b], and O. S. Reshetnyak[b]

[a] *Hydrochemical Division, Water Problems Institute, Russian Academy of Sciences*

[b] *Hydrochemical Institute, prosp. Stachki 198, Rostov-on-Don, 344090 Russia*

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Abstract—The structure of hydrobiocenosis communities in Lena River mouth area is studied. The qualitative and quantitative development characteristics of bacterio-, phyto-, zooplankton, and zoobenthos communities of aquatic organisms in this part of the river are examined. The state and structure of hydrobiocenosis suggest that the mouth area of the river functions under moderate pollution of the aqueous medium.

Keywords: Lena River mouth area; bacterio-, phyto-, and zooplankton, macrozoobenthos, the state of hydrobiocenosis.

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SPECIFIC FEATURES OF THE STRUCTURAL ORGANIZATION OF BIOCENOSIS IN LENA MOUTH AREA

Earlier [5], variations in the hydrological–hydrochemical state of Lena mouth area were studied and a scheme and detailed structure of this part of the river were given. This paper is a logical continuation of those studies.

The study uses many-year (1981–2008) hydrobiological monitoring data of the State Environmental Monitoring Service (SEMS), collected by Tiksi Branch, Yakutsk Department, Hydrometeorological Services (HMS) at monitoring stations at Kyusyur Village., Khabarova St., and in Neelova Bay (Tiksi Settl.).

A specific feature of the structural organization of hydrobiocenosis in Lena Delta is the complete absence of forms typical sea or slightly saline waters [2, 3]. Even in Tiksi Bight, beyond the delta coastline, plankton contains 75% of freshwater, 15% of slightly-saline, and 10% of marine species. The former inhabit surface water, the next inhabit median water, and the latter inhabit bottom water layers. The most common species in phytoplankton composition are Aphanizomenon flosual, Asterionella gracilima, species of Anabaena and Melosira genera (M. islandica, M. granulata).

Zooplankton composition and abundance changes from the delta head to its coastline. Benthic and growth warm-water forms of Cyclopoida, brought by the river (their abundance decreases from banks to the fairways of arms), dominate in the upper parts of arms; single specimens of rotiferas Naxholea lonegispona, Anurca cochlearis and lower crustaceans can be met. Pelagic warm-water Cladocera speices dominate (90–99%) in the lower parts of arms, where flow velocities are less. Their abundance reaches its maximum in August: 500 specimens/m^3 in the upper parts of arms, 2000 in their lower parts, and 2500 specimens/m^3 in the nearshore zone (bar). All the planktonic species mentioned above are warm-water. Zooplankton in lake-like water bodies isolated from the river has a more arctic character [2].

Both the total abundance and the diversity of benthic species also increase toward the delta coastline. During the spring flood (July), only rare larvae of chironimid mosquitoes can be seen on sands. The benthic population rapidly increases by the autumn level drop, when sands enrich with silt and the bottom layers of soils are made more salty by surge water. Oligochaetes Propappus volki, Amphipoda, and pea-mollusks Pisidium appear. In Lake Melkoe, which is episodically connected with the river, the benthos composition extends at the expense of mollusks, crustacean, beetles, and caddis flies larvae [2].

Amphipoda, typical of slightly saline water, appear at the delta coastline, where bottom water salinity is 1‰. The benthic fauna in Neelova Bay is richer and more diverse. Chironomid mosquito larva are absolutely absent here. Typical riverine oligochaetes Limnodrilus are predominant. The anthropogenic transformation of the component composition of the aqueous medium in river mouth area [5] causes space and time variations in individual community of aquatic organisms.

Table 1. Space and time variations in development indices of bacterioplankton communities in Lena mouth area (here and in Tables 3, 4, 8, and 12, b.d.l. means below detection limit)

Region	Observation period, years	Total abundance of	
		microorganisms, million cell/ml	saprophyte bacteria, thousand cell/ml
Lena R., Kyusyur V.	1981–1985*	b.d.l.–121	b.d.l.–63.0
Bykovskaya Arm–polar Khabarova St.	1981–1985	b.d.l.– 9.8	b.d.l.– 3.0
	1986–1990	b.d.l.–3.72	b.d.l.–3.3
	1992–1996	0.17–1.70	b.d.l.–2.4
Tiksi Bight	1980–1985	0.07–262	0.006–600.0
Neelova Bay	1981–1985	0.08–17.4	0.01–45.0
	1993–1996	0.04–17.0	b.d.l.–600.0
Bulunkan Bay	1980–1991	0.03–69.1	0.02–250.0
Buor-Khaya Bay	1980–1994	0.09–6.0	0.009–25.0

* Here and in Tables 8, 12, no further determinations were made.

Table 2. Development of individual bacterial species in Bulunkan Bay [3] (dash means no data available)

Observation years	Abundance, thousand cell/ml			
	bacterioplankton	bacteria		
		saprophytes	hydrocarbon-oxidizing	phenol-oxidizing
1987	220	24	–	–
1988	110–760	25	0.0006–8.4	0.06
1989	170–1100	11	0.55–150	18–46
1990	30–500	0.03–1.7	2.5	0.05
1991	100–570	0.025–6.0	0.25–250	–

BACTERIOPLANKTON COMMUNITY OF AQUATIC ORGANISMS

Earlier studies [1, 2] and analysis of available SEMS hydrobiological monitoring data [3, 4] show that the space and time variations in the total bacterioplankton population and the abundance of saprophytic bacteria are considerable.

The most optimal conditions for microorganism development form in the main channel of the river at Kyusyur Village and in Tiksi Bight, where the maximal abundance was 121 and 262 million cell/ml, respectively (Table 1). Maximal abundance of saprophyte bacteria (up to 600 thousand cell/ml) is periodically recorded in Tiksi Bight.

In September 1991, the total abundance of bacterioplankton in Lena Delta varied from 1.75 to 2.76 million cell/ml, reaching its maximal values at Kyusyur Village [8].

Hydrocarbon- and phenol-oxidizing bacterial species rapidly develop in Bulunkan Bay, the most polluted part of Tiksi Bight [1]. Variations in saprophyte abundance are considerable here against the background of small variations in the total bacterioplankton abundance (Table 2).

Analysis of many-year SEMS monitoring data at the outlet river section and in the Bykovskaya Arm at Khabarova Station suggests the high annual and year-to-year variations in both total bacterioplankton abundance and the abundance of saprophytic bacteria (Table 1). The range of variation sin the most common values (MCV) of the total bacterioplankton abundance is relatively stable: it varied from below detection limit to 2.41 at the outlet section of the river, and from below detection limit to 2.45 million cell/ml in Lena delta.

According to water quality classification in water bodies and streams by hydrobiological characteristics, developed in Roshydromet [6], the aqueous medium of Lena delta can be classified as transitional from pure to moderately polluted.

PHYTOPLANKTON COMMUNITY OF AQUATIC ORGANISMS

The overwhelming majority of phytoplankton species in Lena mouth area belong to freshwater complex; this can be attributed to the strong impact of river runoff throughout the year. Marine species in Neelova Bay

Table 3. Phytoplankton development in Lena mouth area

Mouth area region	Study period, years	Total abundance, thousand cell/ml
Lena R., Kyusyur V	1981–2008	b.d.l.– 3.0
Bykovskaya Arm–polar Khabarova St.	1981–2008	b.d.l.–21.0
Neelova Bay, Tiksi Bight	1981–2008	b.d.l.–0.82
Bulunkan Bay	1980–1990	0.01–1.2
Buor-Khaya Bay	1980– 992	0.03–12.6

are recorded in the periods of autumn setups, when river flow decreases and species can appear that have been brought here by bottom compensation current from the open sea. Winter is the most stable time in phytoplankton development. An increase in the number of species takes place in late winter. The development of algae has two abundance peaks: the first in March–April and the second in August [2].

The spring increase in phytoplankton abundance is due to an abrupt increase in the light day and intense penetration of solar radiation through ice cover. the summer peak of abundance and biomass is due to an increase in water temperature and transparency. Phytoplankton composition was found to contain >100 alga species, including ~60 diatom species, 20 green alga species, 15 blue-green alga species, and 6 flagellates [2].

In winter, diatom algae dominate (~80% of phytoplankton abundance), while the shares of green, blue-green, and flagellates decreases considerably. The most abundanc in the delta are freshwater species, such as Melosira granulata, Asterionella formosa, Diatoma elongatum. In Buor-Khaya Bay, in addition to the mass species mentioned above, marine species appear: Thalassiosira baltica, Choetoceros wighami, Nitzschia frigido, and Achnantas taeniata [2].

Many-year hydrobiological monitoring, carried out by Tiksi HMSD [3, 4] showed that the development of phytoplankton community over the water area of the mouth zone is not uniform (Table 3). The least abundance was recorded in Neelova and Bulunkan bays. The abundance of phytoplankton in river reaches at Kyusyur Village and in Bykovskaya Arm show a wider range of variations. However, the MCV of this characteristic are more uniform (Table 4), varying within 0.05–1.80 thousand cell/ml at Kyusyur Village and 0.0–1.30 thousand cell/ml in the Bykovskaya Arm.

As can be seen from Table 4, phytoplankton development decreases over time. Starting from the 1990s, the maximal values of the abundance of this community never exceeded 2.37 thousand cell/ml at Kyusyur Village and 1.42 thousand cell/ml in Bykovskaya Arm. Flagellates can become abundant in the warm season. For example, in September 1991, their abundance in the Bykovskaya Arm was 760 thousand cell/ml at the depth of euphotic zone of 5 m (Table 5) [8].

The structure of phytoplankton community in the period of its maximal development (Table 6), recorded in August, is mostly represented by diatom algae of genera Melosira and Asterionella.

Table 4. Time dynamics of phytoplankton development in Lena mouth area (here and in Table 12, above the line is the total abundance or the total number of species, below the line is MCV)

Observation period, years	Total abundance, thousand cell/ml		Total number of species	
	Lena R., Kyusyur V.	Bykovskaya Arm, Khabarova St.	Lena R., Kyusyur V.	Bykovskaya Arm, Khabarova St.
1981–2008	b.d.l.–13.0 / 0.05–1.80	b.d.l.–21.00 / 0.05–1.30	0–53 / 5–30	0–45 / 6–25
1981–1985	b.d.l.–2.93	b.d.l.–21.00	0–28 / 9–20	0–26 / 1–25
1986–1990	0.02–13.00	0.02–9.07	4–36 / 10–21	0–34 / 2–22
1991–1995	0.015–1.18	b.d.l.–1.37	3–39 / 3–17	0–42 / 2–21
1996–2000	0.06–2.37	b.d.l.–1.42	1–53 / 6–25	0–39 / 3–18
2001–2005	0.05–0.60	b.d.l.–1.17	1–34 / 4–17	0–45 / 4–18
2006–2008	0.06–0.75	b.d.l.–0.52	1–43 / 6–12	0–16 / 2–10

Table 5. Major groups in phytoplankton community in Lena R. mouth area in September 1991 [6]

Observation region	Number of groups in phytoplankton community		
	cyanobacteria, thousand cell/ml	phytoflagellates	diatoms
		thousand cell/ml	
Lena R.–downstream of Kyusyur V.	18	370	282
Lena R., Kyusyur V.	33	570	371
Bykovskaya Arm–polar Khabarova St.	25	560	360
Bykovskaya Arm–Ebelyakh V.	35	760	320
Olenek Arm	21	470	360

Table 6. Phytoplankton community structure in the periods of its maximal abundance in Lena R. mouth area

Area	Date of maximal abundance (month, year)	Abundance, thousand cell/ml	Species number	Dominating species and their relative abundance, %
Lena R.–Kyusyur V.	08. 1989	5.46	8	Asterionella formosa, 60.9 Melosira granulata, 17.9
	08.1990	13.0	15	Melosira granulata, 51.2 Melosira distans, 19.5
	1996*	2.36	35	Asterionella formosa, 33.8 Melosira granulata, 16.1
Bykovskaya Arm–polar Khabarova St.	07.1982	20.9	16	Asterionella formosa 14.6 Melosira varians, 14.6 Melosira granulata, 13.6
	08.1989	9.1	15	Melosira italica v.val., 40.0 Melosira granulata, 36.7 Asterionella formosa, 10.0
	08. 1990	4.77	13	Melosira italica v.val., 20.9 Asterionella formosa, 23.1 Synedra ulna,18.9 Melosira granulata, 14.7
	08.1992	13.7	13	Melosira granulata, 31 Asterionella formosa, 28 Diatoma elongatum, 28
	09.1996	1.43	15	Asterionella formosa, 23.9 Melosira granulata, 17.2 Fragilaria crotonensis, 13.0
	08.2002	1.18*	32	Melosira granulata, 27.2 Melosira italica v.val., 19.6

* No high values of total phytoplankton abundance were recorded before 2008 (all values are <1.0 thous. cell/ml).

The effect of anthropogenic impact on the biotic component of the ecosystem can be evaluated from statistical characteristics of phytoplankton (the density of variation series (Π_o and the mode of modal interval (M_o)). The obtained values are compared with those in the classifier of the state of water objects [7] to determine the dominating process associated with anthropogenic eutrophication or ecological regress.

In the Lena reach at Kyusyur Village, we have Π_o = 49.9 and M_o = 1.09, while in the Bykovskaya Arm at Khabarova Station, Π_o = 71.3 and M_o = 0.67; both cases show that the development of elements of ecological regress is possible in the ecosystem.

ZOOPLANKTON COMMUNITY OF AQUATIC ORGANISMS

Zooplankton in Lena mouth area is represented by species that either are purely pelagic or live at the bed. The faunistic list includes 160 species of rotiferas, copepods, and crustaceans (cladocerans) (Table 7) [2].

The most diverse zooplankton species composition in Lena mouth area in 1993 was recorded in the Bykovskaya Arm (the number of species is 12 for rotifers, 3 for copepods, and 2 for crustaceans), in the Tumatskaya Arm (18 rotifers, 11 copepods, and 8 crus-

Table 7. Group composition of zooplankton in Lena R. delta in 1993 [2]

Delta arm	Number of species in the group			
	rotifers	copepods	cladoceras	total
Bykovskaya	12	3	2	17
Tumatskaya	18	11	8	37
Great Tumatskaya	22	14	11	47
Great Trofimovskaya	5	2	1	8
Arynskaya	4	2	3	9

taceans), and in the Great Tumatskaya Arm (22 rotifers, 14 copepods, and 11 cruataceans).

The specific features of delta hydrological regime largely determine the appreciable variations in the species composition of zooplankton community. Zooplankton of the Trofimovskaya Arm shows many features in common with that of the main river channel. Thus, in the delta head (Stolb Island), nauplial and copepod stages of copepods and rotifers, dominating among which are Bosmina longirostris, Kellicottia longispina, Acanthocyclops vernalis [2].

In the Bykovskaya Arm, crustaceans Acanthocyclops vernalis and rotifers (Notholla candate) dominate [2].

The entire zooplankton fauna of the Great Tumatskaya Arm can be divided into three complexes: marine, salty-water, and freshwater. The marine complex is represented by cold-water arctic species Acartia longiremis, Acartia glausi. Salty-water organisms belong to autochthonous forms. One of them—Drepanopus bungei—is an endemic of the high-latitude Arctic region. During setup winds, changes can be seen in the zooplankton complex in the lower reaches of the arm because of seawater penetration into the delta [2].

In the lower reaches of this arm, this complex consists of the species of Keratella, Eurytemora, Acarlia, Cyclopina, Limnocalanus. The composition and distribution of zooplankton in the upper part of this arm reflects the influence of the typically river regime of the Lower Lena [2]. Endemics of epicontinental seas of the Arctic Basin occur in Tiksi Bight in summer (Limnocalanus macrurus, Drepanopus bungei, Polyartha major). The share of copopodite stages of those species in Bulunkan Bay increase in summer against the background of accumulation of freshwater crustaceans—Daphnia longispina and Bosmina longirostris [2].

Rotifers of four species—Kellicottia longispina, Keratella quadrata, Keratella cochlearis, and Asplanchna priodonta—form a permanent complex in water of Lena mouth zone.

Anthropogenic impact can be seen in the structural organization and development of zooplankton community where it appreciably changes both the component composition and the extent of pollution of their aquatic habitat.

Analysis of many-year SEMS monitoring data [3, 4] on the qualitative and quantitative characteristics of zooplankton development in some parts of Lena mouth area showed, primarily, an appreciable heterogeneity in its development (Table 8).

The extension of the general range of variations in the abundance of zooplankton community is accompanied by an increase in within-year and year-to-year variations not only in its abundance, but also the species composition with a trend toward the predominance of one or two species. This can be clearly seen in the structural organization of zooplankton in the period of its maximal abundance. The dominating species become rotifers Kellicottia longispina and Keratella cochlearis and cyclopides (Table 9). This suggests the periodic manifestation of an ecological regress of the community.

Table 8. Spatial heterogeneity in zooplankton development in Lena R. mouth area

Mouth area part	Study period	Variation range		Dominating groups
		abundance, thousand spec./m^3	number of species	
Lena R.–Kyusyur V.	1985–1996*	b.d.l.–6.90	1–23	Rotifers Cladoceras Cyclopides
Bykovskaya Arm–polar Khabarova St.	1985–1996	b.d.l.–40.2	1–23	Rotifers Cyclopides Cladoceras
Bulunkan Bay	1987–1992	0.56–25.0	1–9	The same Copepods Crustaceans
Great Tumatskaya Arm	1986–1987	2.48–76.8	up to 72	Copepods Rotifers Cladoceras

Table 9. Structural organization of zooplankton community in the period of its maximal development in Lena R. mouth area

Detection date	Total abundance, thous. (spec./m^3)/number of species	Dominating group and its abundance, thous. spec./m^3	Dominating species and their relative abundance, %
Lena R., Kyusyur V.			
Aug. 17, 1992	6.40/14	Rotifers – 2.90 Cyclopides – 1.80	Cyclopoidae, 18 Bosmina obtusirostris, 10
Aug. 25, 1995	5.77/22	Rotifers – 2.33 Cyclopides – 1.94	Keratella cochlearis, 12 Calonoidae, 11
Bykovskaya Arm, polar Khabarova St.			
Aug. 9, 1986	5.90/7	Cladoceras – 4.95	Sida crystallina, 23 Bosminopsis deitersi, 22
Aug. 28, 1995	6.69/17	Rotifers – 2.23 Cyclopides – 2.14	Cyclopoidae, 15 Calanoidae, 15 Asplanchna priodonta, 11
Aug. 30, 1996	40.2/7	Rotifers – 40.0	Kelicottia longispina, 94

ZOOBENTHOS COMMUNITY OF AQUATIC ORGANISMS

The benthic biocenosis of Lena mouth area is represented by 129 species, including 16 caddis flies, 12 mayflies, 10 caddis flies, 39 larva forms of chironomids, 7 oligochaetas, 7 Limoniidae, 9 species of each of crustaceans, mollusks, and tipulids, 4 species of each of beetles and culicids, and 2 midges [2–5]. Benthos composition in delta arms is governed by the specific features of sedimentation and flow rates.

The arms have their biotopic features, which to one extent or another, are favorable for different types of benthos, thus determining the varying predominance of bottom biocenosis species (Table 10).

The accumulation of organic matter in soils, the freezing regime of the banks and the bed have a direct or indirect effect on the character of benthic fauna distribution. The most densely populated are small arms, pools, and the mouths of creeks and small rivers. Lena main channel within the reach from Tit-Ary Island to Stolb Island has poor benthic fauna. Stony, sandy, and pebble beds dominate here.

The normal vital activity of benthos is hampered by the fact that the river channel from the left to the right bank is a trough with the predominance of pebble soil. The continual motion of stones under the effect of high flow velocities hampers the development of benthic fauna [2].

The species composition of zoobenthos in Bulinkan Bay is represented by organisms not sensitive to water quality and the amount of dissolved oxygen. The oligochaetas inhabiting the bottom soils of the bay in large amounts can withstand considerable phenol and

Table 10. Space and time variations in dominating zoobenthos species in Lena R. mouth arms [2] ((+) is a dominating, (–) is a subdominating, and (0) is a secondary species)

Dominating species	Season		Group
	winter	summer	
Great Tumatskaya Arm			
Heptagenia sulfurea	+	–	Mayflies
Ephemerella ignita	+	0	Mayflies
Hydropsyche bulgoromanorum	+	–	Trichopterans
Cricotopus biformis	–	+	Chironomids
C. bicinctus	0	+	"
Cryptochironomus rolli	+	+	"
Trofimovskaya Arm			
Arcynopteryx altaica	+	0	Caddis flies
A. compacta	+	–	"
Heptagenia fuscogrisea	+	–	Mayflies
C. bicinctus	0	+	Chironomids
Cryptochironomus rolli	–	+	"
Bykovskaya Arm			
C. bicinctus	0	+	Chironomids
Cryptochironomus rolli	+	+	"
Eukieferriella longicalcar L.	–	+	"

Table 11. Total zoobenthos abundance, spec./m^2, and biomass, g/m^2, in Bulunkan Bay in 1987–1993 [2]

Year	Total abundance	Biomass
	mean values	
1987	711	30.4
1988	600	15.6
1989	176	5.83
1990	120	7.8
1991	140	5.6
1992	220	27.6
1993	180	14.4

petroleum pollution and low oxygen concentrations. The character of year-to-year dynamics of the total abundance and biomass of zoobenthos demonstrates considerable variations in the development of benthic organisms in the bay (Table 11).

The Great Tumatskaya Arm features a wide occurrence of silty–sandy and sandy soils. In its upper reach, the community composition shows psammoreophilic biocenosis with the predominance of chironomid larvae (Cryptochironomus rolli). In the lower reach of the arm, salty-water crustaceans (Saduria entomon, Mysis relicta, etc.) dominate in the community. With the distance upstream from the mouth, choronomids dominate in terms of abundance and oligochaeta and mollusks dominate in terms of biomass.

Silty (down to 2-m depth), silty–sandy (2–5 m), and sandy (below 5–6 m) soils dominate in the Trofimovskaya Arm. Caddis flies, mayflies, and chironomids dominate in zoobenthos composition (Table 10).

The benthic population in the Bykovskaya Arm consists of >85% of chironomid larvae and nymphs, oligochaetas and mollusks are co-dominating species.

Analysis of long-term SEMS hydrobiological monitoring data on parts of the Bykovskaya Arm at polar Khabarova Station and on the outlet section of the river at Kyusyur Village [3] showed that, against the background of identical general variation ranges of macrozoobenthos abundance (Table 12), these reaches feature appreciable year-to-year variations in its development. Moreover, the increase in the development of community is determined by the growing

Table 12. Qualitative and quantitative characteristics of zoobenthos development in Lena R. mouth area in 1985–2008 (the number in parentheses below the line is the frequency of MCV, %)

Total abundance, spec./m^2	Relative abundance of oligochaetes, %	Maximal abundance, spec./m^2, detection year	Dominating group and its relative abundance, %
Lena R.–Kyusyur V.			
b.d.l–840 / 120–280 (90)	0–100 / 0–36 (85)	840–1988	Oligochaetes, 62.6 Chironomids, 26.9
		720–1989	Caddis flies, 82
		840–2001	Mollusks, 42.3 Mayflies, 38
		440–2005, 2006	Oligochaetes, 66 Chironomids, 34
		440–2007	Chironomids, 66.2 Trichopterans, 33.8
Bykovskaya Arm–polar Khabarova St.			
b.d.l–850 / 40–280 (83)	0–100 / 0–40 (70)	840–1990	Caddis flies, 69
		840–1992	Mollusks, 40 Chironomids, 30.8
		760–1998	Tipulida, 28 Mollusks, 25 Chironomids, 13
		560–1999	Mollusks, 38.4 Chironomids, 31.6 Oligochaetes, 25.4
		560–2000	Mollusks, 100
		560–2001	Caddis flies, 45.1 Chironomids, 32
		440–2007	Chironomids, 66.2 Trichopterans, 33.8

Table 13. The state of benthic biocenoses in individual arms of Lena R. delta [2]

Depth, m	Abundance, spec./m^2	Biomass, g/m^2	Index		Water purity class
			Woodnight–Whitley	Woodiwiss	
Lower Lena (Stolb Isl.)					
17.6	210	1.2	56	6	Moderately polluted
23.3	120	0.4	35	8	Pure
Sardakhskaya Arm (Sardakh-Ary Isl.)					
5.0	220	3.1	52	2	Polluted
4.3	170	1.7	60	5	Moderately polluted
Great Tumatskaya Arm (Bilir Isl.)					
4.2	140	0.4	61	5	Moderately polluted
4.8	2100	9.1	83	4	Polluted
Barchakhskaya Arm (Kruglyi Isl.)					
23.3	120	0.4	35	8	Pure
3.0	230	3.7	36	8	The same
Trofimovskaya Arm (Cheke Isl.)					
2.0	240	3.4	58	5	Moderately polluted
17.6	210	1.2	56	6	The same

populations of oligochaetas, chironomids, and caddis flies in the outlet section and mollusks, tipulides, and caddis flies in the Bykovskaya Arm (Table 12).

By the development of oligochaete group, according to water quality classifier for water bodies and streams by biological indices, accepted in Roshydromet [6], the aquatic medium in the delta head can be classified as transitional from pure to moderately polluted.

Overall, the water of Lena mouth area, by the state of zoobenthos, can be characterized as pure or moderately polluted; a tendency toward quality deterioration can be seen in some reaches. These include Bulunkan Bay in Tiksi Bight and the northern part of Neelova Bay, because of oil product and phenol pollution of their bottom sediments. In these areas, the trophic links that existed in zoobenthos were found to be disturbed and the species diversity radically declined.

Estimates of Goodnight–Whitley and Woodiwiss indices [2] showed the purity class of the aquatic medium by the state of zoobenthos appreciably varies over the zones of the river's mouth area (Table 13). While water quality in the delta was assessed as transitional from pure to moderately polluted, that in the Sardakhskaya and Great Tumatskaya arms was assessed as transitional from moderately polluted to polluted.

It is likely that the state of ecosystems in the arms shows a negative effect of the slower flow in river delta and the consequent decrease in bottom water aeration, as well as the accumulation of pollutants in the active silt layer [2].

CONCLUSIONS

Analysis of the results of hydrobiological observations in Lena River mouth area shows that the development and state of hydrobiocenosis, especially, zoobenthos, is largely determined by the existing complex of hydrological and hydrochemical features and the character of biotope. The presence of permanent flows with relatively high speeds in major arms of the delta ensures good aeration of bottom water layers. The considerable assimilation capacity of delta hydraulic system suggests the slow rates of pollution of water and bottom sediments because of sufficient self-purification capacity of water.

In the foreseeable future, the continuing anthropogenic impact, primarily, oil pollution, can become detrimental for aquatic organism communities.

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