Hydrobiological Characteristics of Lake Tayinty

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Abstract. The article provides the findings of a hydrobiological study on Lake Tayinty located in Ulan District of East Kazakhstan Province. For the first time ever, data is provided on the present-day condition of the lake's phyto- and zooplankton and macrozoobenthos. The study has identified 29 species of algae within the lakes's phytoplankton and 12 taxa within its zooplankton. The values for the density and biomass of zooplankton on the Kitaev trophicity scale indicate a high level of productiveness on the part of the lake's plankton invertebrates. By the M.L. Pidgaiko et al. fishery classification, the lake belongs to the eutrophic type. The lake's macrozoobenthos includes 13 taxa. By the values for macrozoobenthos biomass, the lake belongs to the β-mesotrophic class. By the values for the development of macrozoobenthos, the quality of surface waters is Class III, which puts the lake in the moderate pollution category.
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Introduction

Currently, hydrobiological studies are applied only in solving crucial problems arising out of significant issues in the water economy both in the area of providing for the protection of water bodies against pollution and other negative consequences of anthropogenic impact and creating the necessary conditions for fisheries.

There has practically been little to no hydrobiological research on the numerous lakes of Eastern Kazakhstan. In the meantime, the anthropogenic load in the form of recreational load is growing, since Eastern Kazakhstan is becoming popular and convenient for tourism and recreation, with resorts built actively on the lake's shore. We have conducted a detailed hydrobiological study of Lake Tayinty.

Methods.

Our field hydrobiological study of Lake Tayinty was conducted from August 26 to September 23, 2013. The determination of the geographical coordinates, elevation above sea level, and dimensions of the lake was carried out using applied methods, 1:100,000- and 1:200,000-scale topographic maps, and readings of GPS satellite navigation devices. The orography of landscapes surrounding the lake basins and the degree of shoreline indentation were described visually; the nature of the ground was registered; the availability and patterns of distribution of higher water vegetation were assessed. The transparency and temperature of water were determined in the different bottom horizons.

Sampling was performed on three points: Point 1 – the southern shore of the left wing; Point 2 – the middle of the water body; Point 3 – the northern shore of the left wing with the coordinates (based on GPS data) $N49^0 26.498`$ E $083^0 03.500`$.

The study was conducted in accordance with commonly accepted hydrobiological analysis methods [1,2,3,4,5,6,7,8].

Phytoplankton was sampled in 1-liter plastic vessels and formalin-fixed until a final formalin concentration of 2% was attained, with subsequent fixation, condensation, and sedimentation.

Zooplankton was sampled through sampling the entire water column (from bottom to surface) using the Juday net and fixed in 4% formalin.

The lake's macrozoobenthos was sampled using a 1/40 m^2 Petersen grab.

The hydrobiological study included:

1. On phytoplankton – the determination of the taxonomic composition of algae; the determination of the dominant complex of species; overall density and biomass, as well as the overall density and biomass of main groups; the calculation of the Pantle-Buck saprobity index and assessment of the quality of surface waters; the determination of the water body's trophicity on the S.P. Kitayev scale [2, 5, 9, 10].

2. On zooplankton – the determination of the taxonomic composition; the determination of the dominant complex of species; overall density and

biomass, as well as the overall density and biomass of main groups; the calculation of the Pantle-Buck saprobity index; the calculation of the Shannon-Weaver species diversity index; the assessment of the quality of surface waters; the determination of the water body's trophicity on the S.P. Kitayev scale; the determination of the food capacity type by the M.L. Pidgaiko fishery classification [3, 6, 11].

3. On macrozoobenthos – the determination of the taxonomic composition; the determination of the dominant complex of species; overall density and biomass, as well as the density and biomass of main groups; the calculation of the Woodiwiss biotic index, the oligochaete index, and the Shannon-Weaver species diversity index; the assessment of the quality of the lake's waters [12,13,14].

4. Toxicity was determined using the test object Daphnia magna [15].

Main part.

The Tayinty impoundment is located in the Ablaket rural okrug of Ulan District of East Kazakhstan Province at a height of 837 m above sea level in the middle reaches of the River Tayinty at a distance of 85 km from the region's capital, Ust-Kamenogorsk, 3.5 km from the village of Tayinty. The River Tayinty is a first-order tributary of the River Irtysh. The distance from the river's estuary to the water body is 20 km. The impoundment's square area is 87.5 ha. The drainage square area is 87.5 ha. The impoundment's length is 2.0 km. The average width is 0.3 km. The maximum width is 0.5 km. The maximum depth is 20 m; the average depth is 3.5 m. The square area of the shallow water zone (the littoral zone) with a depth of up to 2 meters is 4 ha. The total storage is 3.8 million m³. The live storage is 3.05 million m³. The length of the shoreline is 5.3 km. The coordinates of the location of the fishery water body are N 49º26'34.4″ E 83º03'26.6″. The water body type is artificial, channel. The hydrosystem is under the supervision of the akimat of Ulan District. The water from the impoundment is used for the irrigation of agricultural cultures, amateur fishing, and recreational purposes.

The lake basin is U-shaped and is stretched out from the south to the north.

The phytoplankton of Lake Tayinty. In August 2013, 29 species of algae divided into two departments were identified within the phytoplankton of Lake Tayinty: diatoms (Bacillariophyta) – 20 species or 69% and the green (Chlorophyta) – 9 species or 31% (Table 1). On the whole, by frequency the lake is dominated by diatoms: *Asterionella formoza* (o-β) and *Fragillaria crotonensis* (o-β).

Table 1. The taxonomic composition of phytoplankton in Lake Tayinty

Taxon	Frequency, %	Point 1	Point 2	Point 3
Bacillariophyta				
Achnanthes lanceolata	33			+
Achnanthes minutissima	100	+	+	+
Asterionella formosa	100	+	+	+
Cocconeis placentula	100	+	+	+
Cocconeis placentula var. intermedia	33	+		
Cyclotella menenghiniana	67	+	+	
Cymbella cistula	33	+		
Cymbella lanceolata	33			+
Cymbella ventricosa	100	+	+	+
Diatoma vulgare	67	+	+	
Diatoma hiemale var. mesodon	67	+	+	
Gomphonema olivaceum var. calcareum	100	+	+	+
Fragillaria crotonensis	100	+	+	+
Melozira granulate	67		+	+
Navicula cryptocephala var. veneta	67	+	+	
Navicula rhynchocephala	67		+	+
Nitzschia palea var. capitata	33		+	
Synedra acus	33	+		
Synedra ulna	67	+		+
Synedra ulna var. amphyrhynchus	33		+	
Clorophyta				
Ankistrodesmus longissimus var. acicularis	100	+	+	+
Coelastrum microporum	33		+	
Closterium moliniferum	33	+		
Lambertia ocellata	67	+	+	
Pandorina morum	100	+	+	+
Peridinium cinctum	33		+	
Sphaerocystis planctonica	67	+		+
Tetraedron minimum	33		+	
Volvox globator	33		+	

The taxonomic abundance of algae varied across the observation stations. The largest species wealth was recorded at Point 2 – 22 species. In the littoral parts of the water body, a decrease in species abundance was observed. Thus, 19 species of algae were identified in a sample in the southern part of the left wing (Point 1). The study observed a decrease in the number of species down to 15 in the littoral zone of the northern shore of the left wing (Table 2).

Table 2. Phytoplankton species abundance at Lake Tayinty observation stations in August 2013

Observation stations	Point 1	Point 2	Point 3
Number of species	19	22	15

In terms of quantity, the richest phytoplankton was recorded at Point 1, its density 3515.3 thousand c/l, biomass 3.5888 mg/l. The largest share in forming this point's biomass was with the diatom alga *Fragilaria crotonensis* Kitton., its density 2466.7 thousand c/l, biomass 2.3680 mg/l. At Point 2, the overall density of algae was 1551.8 thousand c/l, biomass 1.5217 mg/l. The prevalent algae were the diatom algae *Asterionella formosa* Hass. and *Fragillaria crotonensis* Kitton., which made up the basis of the density and biomass of phytoplankton. The poorest phytoplankton with a density of 510.2 thousand c/l and a biomass of 0.6036 mg/l was detected at Point 3 (Table 3).

Table 3. The dynamics of values for the density and biomass of phytoplankton in Lake Tayinty in August 2013

Department	Point 1		Point 2		Point 3		Average	
	density, thou. c/l	biomass, mg/l	density, thou. c/l	biomass, mg/l	density, thou. c/l	biomass, mg/l	density, thou. c/l	biomass, mg/l
Bacillariophyta	3231,9	2,8964	1173,4	0,9641	438,5	0,3897	1614,6	1,4167
Chlorophyta	283,4	0,6924	378,4	0,5576	71,7	0,2139	244,5	0,4880
Total	3515,3	3,5888	1551,8	1,5217	510,2	0,6036	1859,1	1,9047

The degree of the development of phytoplankton in Lake Tayinty corresponded to the lowest productivity class. The average phytoplankton biomass in the water body was 1.9047 mg/l, which classifies it under the ultraoligotrophic water body type with the lowest productivity class (Table 4).

Table 4. The trophicity and productivity of phytoplankton by biomass in Lake Tayinty in 2013

Sampling station	Phytoplankton biomass, g/m^3	Type of water body	Productivity class
Point 1	0,0036	ultraoligotrophic	lowest
Point 2	0,0015	ultraoligotrophic	lowest
Point 3	0,0006	ultraoligotrophic	lowest

The saprobity index calculated on phytoplankton at the three study points varied in the range of 1.63 and 1.64, which is Class III (moderate pollution) (Table 5).

Table 5. The values of the saprobity index for phytoplankton in Lake Tayinty in 2013

Observation stations	Point 1	Point 2	Point 3
Saprobity index	1,64	1,63	1,63

Most of the species and varieties discovered within the lake's phytoplankton were indicators for a particular saprobity zone. By frequency, most of the indicator species belonged to o-β-mesosaprobs [16-18].

No eutrophication and algal blooms were observed.

Zooplankton. The study discovered 12 taxa within the zooplankton complex in Lake Tayinty in September 2013: 5 Rotifera, 2 Copepoda, and 5 Cladocera. The taxonomic composition of the lake's zooplankton is provided in Table 6.

Table 6. The taxonomic composition of zooplankton in Lake Tayinty in September 2013

Taxon	Saprobity zone	Frequency, %	Point 1	Point 2	Point 3
Rotifera					
Polyarthra dolichoptera Idelson	o	33		+	
Asplanchna priodonta Gosse	o-β	67	+	+	
Keratella cochlearis (Gosse)	β-o	33			+
Keratella quadrata (Muller)	o-β	33		+	
Conochilus sp.		33		+	
Copepoda					
Cyclops vicinus (Uljanine)		33			+
Mesocyclops leuckarti (Claus)		67	+		+
Cladocera					
Bosmina longirostris (Muller)	o-β	67	+	+	
Daphnia galeata Sars	o	100	+	+	+
Daphnia cucullata (Sars)	o-β	33	+		
Simocephalus vetulus (Muller)	o-β	33			+
Ceriodaphnia quadrangula (Muller)	β	100	+	+	+
Total number of species in sample		-	6	9	6

Let us examine the spatial characteristics of the quantitative values for the lake's zooplankton.

In the southern part of the left wing shore (Point 1), zooplankton density and biomass were in the moderate productivity class (Table 7). This part was dominated by cladocerans *C. quadrangula*, which are filter feeders in the trophic chain.

In the lake's pelagic zone (Point 2), the value of biomass was 2570 mg/m^3, which on the Kitayev trophicity scale corresponds to the medium productivity class. The major contribution to density and biomass values in this part of the lake came from cladocerans *D. galeata*.

In the littoral zone of the northern shore of the lake's left wing (Point 3), the study recorded the highest quantitative values for zooplankton (Tables 6 and 7). The values for zooplankton density and biomass on the Kitayev trophicity scale corresponded to a high level of productivity in plankton invertebrates [2, 5].

Table 7. Lake Tayinty study station characterization

Station	D, m	V, l	Dens., thou. ind./m^3	Biom., mg/m^3	DD	BD	TC	FC
Point 1	2,0	100	106,5	1930	*C. quadrangula*	*C. quadrangula*	moderate	medium food capacity
Point 2	11,0	380,6	108,2	2570	*D.galeata*	*D.galeata*	medium	food capacity higher than medium
Point 3	2,0	69,2	572,1	11963	*D.galeata*	*D.galeata*	high	very high food capacity

Abbreviations: D – depth; V – volume of filtered water; dens. – density; biom. – biomass; DD – dominants by density; BD – dominants by biomass; TC – Kitaev trophicity class; FC – type of food capacity by the fishery classification

On the whole, in terms of density (60-72% from total density) and biomass (82-94%) the lake's zooplankton was dominated by cladocerans. The average values for zooplankton density and biomass in Lake Tayinty were 262.3 thousand ind./m^3 and 5487 mg/m^3 respectively (Table 8). These values

point to the increased productivity class. By the M.L. Pidgaiko et al. fishery classification [6], Lake Tayinty belonged to the high food capacity water body type in August 2013.

Table 8. The dynamics of values for zooplankton density and biomass in Lake Tayinty in September 2013

Groups of zooplankters	Point 1		Point 2		Point 3		average	
	density, thou. ind./m³	biomass, mg/m³	density, thou. ind./m³	biomass, mg/m³	density, thou. ind./m³	biomass, mg/m³	density, thou. ind./m³	biomass, mg/m³
Rotifera	20,5	59	20,5	48	1,4	2	14,1	36
Copepoda	22,5	147	10,0	91	160,4	2142	64,3	793
Cladocera	63,5	1724	77,7	2430	410,3	9819	183,8	4658
Total	106,5	1930	108,2	2569	572,1	11963	262,3	5487

Out of 12 taxa of zooplankton organisms, nine were saprobity indicators. The study recorded the prevalence of o-β-mesosaprobic species within zooplankton.

The values of the saprobity index calculated on zooplankton at the three study points varied within Class II from 1.10 to 1.36, and the average value was 1.19, which corresponds to Class II (clean water) (Table 9).

Table 9. The saprobity index and the Shannon-Weaver species diversity index for zooplankton in Lake Tayinty in September 2013

Variables	Point 1	Point 2	Point 3	Average
Saprobity index	1,36	1,10	1,10	1,19
Shannon-Weaver species diversity index	2,39	1,81	1,41	1,87

The dynamics of taxonomic abundance is reflected by the Shannon-Weaver species diversity index, which shows the amount of information for one species. It was propounded in 1963 for assessing the structuredness of biocenoses as the degree of the system's orderliness (informedness). Usually, negative anthropogenic impact leads to decrease in the number of species in communities (due to the disappearance of stenobionts) and impairs the evenness of values of their population density. Therefore, the values of the Shannon index expectedly diminish amidst pollution. Thus, in polluted waters, the Shannon index is less than 1.00, in highly polluted waters – less than 0.5, in clean waters – from 2.00 to 3.00, and in very clean waters – higher than 3.00.

In using the Shannon-Weaver species diversity index, calculated by density, the study obtained average values that characterize Lake Tayinty as an oligotrophic water body with moderately polluted water quality (Table 8). The study recorded the most structured hydrobiocenosis in the lake's littoral zone. Here the value of the species diversity index was 2.39, which corresponds to Class II – clean water [16-18].

Macrozoobenthos. The study discovered 13 taxa within the taxonomic composition of Lake Tayinty's macrozoobenthos in September 2013: leeches (1 species), molluscs (3 species), crustaceans (1 species), insects (6 species), as well as oligochaetes and arachnids. The taxonomic composition of the lake's macrozoobenthos is provided in Table 10.

Table 10. The taxonomic composition of macrozoobenthos in Lake Tayinty in September 2013

Taxa	Frequency, %	Point 1	Point 2	Point 3
Class Hirudinea				
Helobdella stagnalis (Linne)	33	+		
Class Oligochaeta				
Oligochaeta sp.	67		+	+
Class Bivalvia				
Euglesa sp.	33	+		
Class Gastropoda				
Valvata cristata (Muller)				
Lymnae auricularia (Linne)	33	+		
Class Crustacea				
Micruropus wahli (Dybowski)	67	+		+
Class Arachnidae				
Hydrocarinae sp.	33			+
Class Insecta				
Order Ephemeroptera				
Caenis miliaria (Tshern.)	33	+		
Order Diptera larvae				
Endohironomus sp.	67	+		+
Glyptotendipes sp.	33	+		
Chaoborus. sp	33		+	
Chironominae sp.	33			+
Order Megaloptera				
Sialissordida (Klingstedt)	33	+		

The largest taxonomic diversity was recorded at the lake's southern shore. In the macrozoobenthos sample, the study registered crustaceans, ephemeral larvae, molluscs, leeches, and insect larvae. By density and biomass, the lake's macrozoobenthos was dominated by crustaceans, which were represented by one species, *Micruropus wahli*, with a density of 1078 ind./m² a biomass of 2.8028 g/m² (Table 11).

In the central part of the water body, the study discovered only oligochaetes and Chaoborus midge larvae. The values for density and biomass in the water body's central part are comparable to those at the southern shore (Table 11).

Table 11. The dynamics of values for zoobenthos density and biomass in Lake Tayinty in September 2013

Main groups of invertebrates	Point 1		Point 2		Point 3		average	
	density, ind./m²	biomass, g/m²	density, ind./m²	biomass, g/m²	density, ind./m²	biomass, g/m²	density, ind./m²	biomass, g/m²
Oligochaeta	-	-	160	0,1600	80	0,0800	120	0,1200
Hirudinea	1	0,0306	-	-	-	-	1	0,0306
Mollusca	5	0,1627	-	-	120	2,0000	63	1,0814
Crustacea	1078	2,8028	-	-	2680	6,9680	1879	4,8854
Diptera	62	0,1530	880	3,6960	600	1,1960	514	1,6817
Megaloptera	2	0,0460	-	-	-	-	2	0,0460
Ephemeroptera	1	0,0013	-	-	-	-	1	0,0019
Arachnidae	-	-	-	-	40	0,0080	40	0,0080
Total	1149	3,1964	1040	3,8560	3520	10,2520	1903	5,7681

The maximum values for the development of macrozoobenthos were recorded at the Lake Tayinty's northern shore. The study recorded 5 animal taxa within the bottom community of invertebrates: crustaceans (1 species); dipterans (1 species); molluscs (1 species), oligochaetes, and the water spider. The study recorded at this point the maximum values for density (3520 ind./m²) and biomass (10.2520 g/m²).

The average value for macrozoobenthos density in Lake Tayinty was 1903 ind./m² and biomass 5.7681 g/m². Based on the trophicity scale, by the values for macrozoobenthos biomass Lake Tayinty belongs to the β-mesotrophic class, i.e. the medium trophicity level.

The saprobiological analysis of the taxonomic composition of the lake's macrozoobenthos pointed to the prevalence of moderate water body pollution indicator species. To assess the water's quality, the study employed the Woodiwiss biotic index, the oligochaete index, and the Shannon-Weaver species diversity index.

By the values for the development of macrozoobenthos, the quality of Lake Tayinty's surface waters was evaluated as Class III, which is the moderate pollution category (Table 12).

Table 12. The dynamics of values for zoobenthos density and biomass in Lake Tayinty in September 2013

Main groups of invertebrates	Number of species	Shannon-Weaver index	Oligochaete index	Woodiwiss biotic index	Quality class
Point 1	9	0,4	-	6	III
Point 2	2	0,6	0,15	-	III
Point 3	5	1,1	0,02	-	III

Inferences.

In August 2013, the study identified 29 species of algae divided into 2 departments within the phytoplankton of Lake Tayinty: diatoms (Bacillariophyta) - 20 species or 69% and the green (Chlorophyta) - 9 species. The degree of the development of phytoplankton in Lake Tayinty corresponds to the lowest productivity class, which classifies it under the ultraoligotrophic water body type. By the saprobity index calculated for phytoplankton, the lake is in Class III (moderate pollution). Most of the phytoplankton indicator species belong to o-β-mesosaprobs. No eutrophication and algal blooms were observed.

The study identified 12 taxa within the zooplankton complex in Lake Tayinty in September 2013. The values for phytoplankton density and biomass on the Kitaev trophicity scale indicated a high level of productivity on the part of plankton invertebrates. By the values of zooplankton density and biomass in Lake Tayinty, it belongs to increased productivity class lakes. By the M.L. Pidgaiko et al. fishery classification, Lake Tayinty belongs to the eutrophic water body type. The study recorded the prevalence of o-β-mesosaprobic species in the lake's zooplankton. By the saprobity index and the Shannon-Weaver species diversity index calculated for zooplankton, the lake is in Class II (clean water).

The study identified 13 taxa within the lake's macrozoobenthos in September 2013. The largest taxonomic diversity was recorded at the lake's southern shore. Based on the trophicity scale, by the values for macrozoobenthos biomass the lake belonged to the β-mesotrophic class, i.e. the medium trophicity level. The saprobiological analysis of the taxonomic composition of the lake's macrozoobenthos points to the prevalence of moderate water body pollution indicator species. By the values for the development of macrozoobenthos, the quality of Lake Tayinty's surface waters was evaluated as Class III, which is the moderate pollution category.

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