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APPLIED PROBLEMS OF ARID LANDS DEVELOPMENT

Zooplankton and Water Quality of the Ishim River in Northern Kazakhstan

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Abstract—The article presents data on a reconnaissance survey of the ecological condition in the middle reaches of the Ishim River in North Kazakhstan oblast. An assessment based on bioindication methods is given for the ecological condition of the river. The research presents data on the saprobity and quantitative indicators of zooplankton at different river stations. The presence of *Ergasilus sieboldi* Nordmann has been identified in the Sergeevskoe reservoir.

Keywords: zooplankton, Ishim, ecology, bioindication, saprobity
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INTRODUCTION

The water quality condition in Kazakhstan water systems has become a threat to public health and economic development. The Decree of the Government of the Republic of Kazakhstan No. 1176, dated November 9, 2010, “On the Approval of the Ak Bulak Program for 2011–2020” has resolved the issue of planned support for the water supply system in the country. In 2008–2010, at the request of the Government of Kazakhstan, the Institute of Water and Environmental Problems, Siberian Branch, Russian Academy of Sciences, in cooperation with the Kozybaev North Kazakhstan State University, the Ministry of Education and Science of the Republic of Kazakhstan, conducted research titled "Study of the Regularities in the Formation and Functions of Northern Kazakhstan Water Systems as Drinking Water Sources for the Population.”

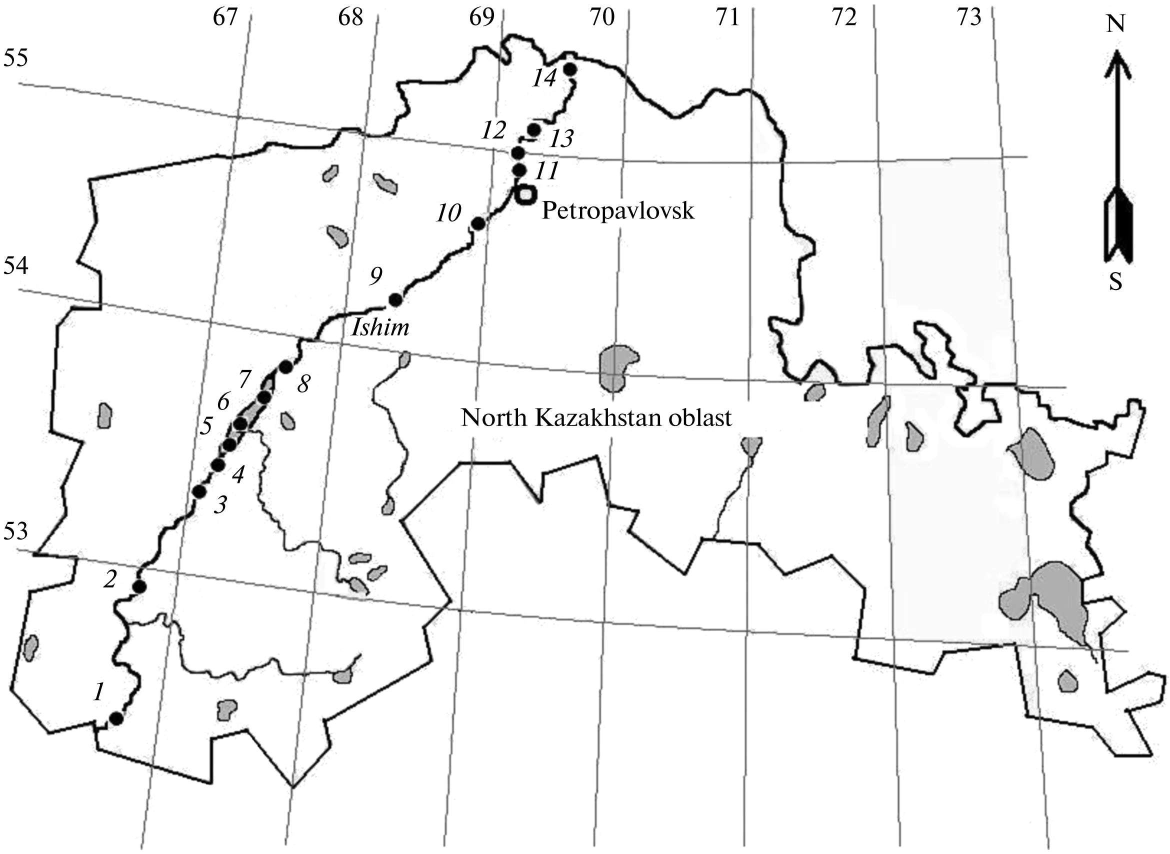
The river system of North Kazakhstan oblast is poorly developed. The major source of water supply is the Ishim River. The river flows through the areas that are the most intensively used for agriculture (Aleshina et al., 2009). There are a few large cities on the river, including the capital of Kazakhstan, Astana. The Ishim waters are used for a wide variety of purposes, including as a water supply for the population and the satisfaction of their domestic needs and household and industrial purposes. A fall of the river water level, which was due to a growth in water consumption, has lead to significant adverse changes in the hydrological and hydrochemical river conditions and transformed the biota (Novikova et al., 2011). In addition, wastewater in Astana are planned to be discharged into the Ishim river after their treatment and processing beginning in 2016. According to experts’ predictions, about 150 thousand cubic meters of processed and treated water will annually flow into the river. If we do not properly treat discharged wastewaters, they will degrade the downstream water quality. Therefore, the condition of the Ishim River and the quality of its water require constant ecological monitoring. Along with hydrological and hydrochemical monitoring methods, it is necessary to carry out hydrobiological monitoring by bioindication methods based on indicators of the condition of organism populations (Gubanova, 2012).

Our goal was to characterize the contemporary condition of reservoirs and watercourses in North Kazakhstan oblast by means of bioindication methods with zooplankton, which makes it possible to promptly assess the level of eutrophicity in the reservoir and the potential for its self-purification.

MATERIALS AND METHODS

Zooplankton samples collected in July 2009 and July 2010 at nine stations of the Ishim River and in the Sergeevskoe (station nos. 5–7) and Petropavlovskoe (station nos. 11–12) reservoirs served as the material for this work (Fig. 1). Sampling was performed at three plants of each station (the right and left banks and the center) based on a screening of 50 liters of water through a plankton Apstein net (gas no. 72) and was fixed with 4% formalin and treated by means of generally accepted methods in hydrobiology (*Rukovodstvo*..., 1992).

When the Shannon index $H = -\sum p_i \log_2 p_i$ was calculated, the abundance and biomass indicators



Schematic map of the Ishim River stations in Northern Kazakhstan (the numbers of stations correspond to the numbers in Table 3 and in the text of the article).

were taken into account, since this calculation option harmoniously combines both abundance factors (Rozenberg, 2010). The following calculation of p_i probability was used in the index:

$$p_i = (N_iB_i)^{1/2}/\sum(N_iB_i)^{1/2}, \quad (1)$$

where $(N_iB_i)^{1/2}$ is the population density index (Rozenberg, 2010).

To assess the ecological condition of watercourses, a bioindication method based on the Pantle-Buck saprobity index was used (Slàdeček, 1973). In the calculation of this index, the values of regional indices of indicator significance obtained for zooplanktonic organisms of reservoirs in the south of western Siberia were used; the level of eurybiontity and stenobiontity of zooplanktonic organisms was assessed by their indicator weight (Ermolaeva and Dvurechenskaya, 2013, 2014a). The level of stability and resistance of the zooplankton community was assessed by species diversity (Shannon index, H) (Alimov, 2000).

The environmental characteristics of species (phytophils, pelagobionts, etc.) are assumed according to a number of major reviews on zooplankton ecology (Chuikov, 2000; *Annotirovannyi…*, 2001, 2009; Radwan et al., 2004).

The length of the Ishim River is 2450 km; the water catchment area is 177 thousand km^2. Northern Kazakhstan oblast covers a section of the river with a length of 690 km. The Ishim near Petropavlovsk flows from southwest to northeast. Downstream of the town of Sergeevka, the river opens onto the West Siberian Plain and flows along the flat Ishim Plain in a large floodplain with numerous former riverbeds; it further flows among bogs in the lower reaches and runs into the Irtish near the city of Ust'-Ishim. The river's channel is circuitous, with a width of 40 to 200 m. The bottom is mainly sandy. The depths are 0.1–0.3 m at the ripples and up to 8–10 m in the reaches. The average width of the valley is from 4 to 22 km. The river is snow fed. The spring flood peak is in May to June. The Ishim mineralization varies from 0.3 to 0.7 g/L, depending on the season of the year. In the oblast, the river channel is regulated by the Sergeevskoe and Petropavlovskoe reservoirs. The Sergeevskoe reservoir was formed in 1969. Its length is 75 km and width is 7 km. The maximum depth is 20 m, and the water volume is more than 693 million m^3. The Petropavlovskoe reservoir is constructed on the Ishim River almost within the boundaries of the city. The reservoir is of run-of-river type, the water-surface area is

9.7 km^2, the mean depths are 4–5 m, and the volume is 19.2 million m^3.

At present, the water level in the Ishim River has decreased by several meters. Although there are no industrial enterprises on the river, its water is contaminated by the local population. The riverbanks are full of different types of garbage and domestic waste. When there is a flood flow, all of these products, together with melt waters, enter the river. Over the past years, the Ishim River is in the third class with respect to water quality, i.e., it has "moderately polluted" water (WPI = 1.41). The MAC was observed to be excessive with respect to the total iron (1.9 MAC) and zinc (3.4 MAC). The Sergeevskoe reservoir is characterized as "clean" (class 2, WPI = 0.93). The content of pollutants is also excessive with respect to the concentration of the total iron and zinc (up to 1.6 MAC). At some sites, BOD$_5$ was observed to be excessive by 1.5–2.0 times (up to 4.32 mg of O$_2$/dm^3) (Dolmatova, 2011; Kirillov et al., 2011).

The Ishim River is poorly studied in terms of hydrology. There are few works on planktonic organisms (Pil'guk, 1973; Pil'guk and Zholbolsynova, 1981; Aleshina, 2009; Akbaeva et al., 2012); in addition, they have an incidental nature. In light of the increasing anthropogenic load, the regular performance of such studies should be adopted to monitor changes in the river ecosystem. The goal of this research was to study the taxonomic structure and quantitative characteristics of zooplanktonic communities and, based on the obtained data, to assess the ecological condition of the Ishim River in Northern Kazakhstan.

RESULTS

Eighty-seven species were recorded as part of the Ishim River zooplankton in Northern Kazakhstan (Table 1). The zooplankton representatives belong to three basic taxonomic groups: Cladocera, Copepoda, and Rotifera. Copepod crustaceans are characterized by the lowest species diversity, with 21 taxa identified among them. Twenty-eight taxa were identified among cladocerans. Rotifers showed the largest diversity in zooplankton (38 taxa). The predominance of this group over entomostracans in terms of quality is characteristic of river plankton. On the whole, the number of species significantly varies from one section to another, which is due to the morphological and hydrological peculiarities of the river, as well as to the different levels of anthropogenic impact on them.

The quantitative zooplankton indicators and the species structure of the community are markedly different at the different studied stations (Table 2). Data on 2009 and 2010 are given for some stations that make it possible to assess the interannual variability of the analyzed indicators (Tables 1 and 2).

The values of the Shannon species diversity index (H) and the Pantle-Buck saprobity index for all of the studied sections are given in Table 3.

Below, separate river stations are characterized.

5-km Upstream Razgul'noe village (station no. 1). Ripple. The depth was 0.4 m., and the water temperature was 23.0°C. The bottom ground site is crushed stone and medium fine. Eighteen zooplanktonic species were identified (Table 1). Their abundance and biomass were low (Table 2). *Mesocyclops leuckarti* Claus nauplii and copepodites were dominant (20% of the total abundance). Low values of the Shannon index ($H < 2.0$) (Table 3) indicate the presence of transformed monodominant biocenosis in this section.

Upstream Zapadnoe village (station no. 2). Ripple. The depth was 0.4 m., and the water temperature was 24.2°C. The bottom ground is the same as that in the upper section. Zooplankton was represented by 22 species (Table 1). The abundance and biomass is somewhat higher than those at the upper station (Table 2). These indicators are characteristic of slow-flowing reaches with upper aquatic vegetation. Nauplii and copepodites, *Thermocyclops oithonoides* Sars, were dominant (13% of the total abundance). This species is an indicator of elevated organic pollution. The indicator value index calculated for the given species in the reservoirs of the south of western Siberia is 2.33, which corresponds to a-mesosaprobic habitat conditions (Yermolaeva and Dvurechenskaya, 2013, 2014a). There were also numerous *Keratella quadrata quadrata* (Müller)) and *Euchlanis deflexa deflexa* Gosse (13% and 12%, respectively). A transformed biocenosis dominated by two–three β-mesosaprobic species was observed. Free-swimming male *Ergcisilus sieboldi* Nordmann were found in the plankton.

Near Kupriyanovka village (station no. 3). The bottom ground is rubbish and gravel. The depth of the watercourse did not exceed 1 m, with the soil being 90% covered by phytoperiphyton. The water temperature was 24.9°C. Sixteen zooplankton species were recorded (Table 1). Their abundance and biomass were low (Table 2). The majority of them were *M. leuckarti* Claus and *Colurella obtusa* Gosse copepodid stages (25% and 20%, respectively). The Shannon index had low indicators again (Table 3). A transformed biocenosis with a predominance of two species was observed.

Ishim River upstream of the Sergeevskoe reservoir (station no. 4). The bottom has clay with sand admixture. The depth was only 0.7 m. The water temperature was 24.9°C. Thirteen zooplankton species were identified; they were mainly represented by cladocerans and copepods. Rotifers were represented only by two species. The abundance and biomass of zooplankton are rather high for rivers and are characteristic of slow-flowing sections with upper aquatic vegetation or boggy areas associated with former riverbeds and backwaters. *M. leuckarti* Claus eurybionts (all development stages), adult *Cyclops kolensis* Lill. without egg pouches, and *Daphnia longispina* Müller) were dominant (36%, 32%, and 10% of the total abundance,

Table 1. Species composition of zooplankton at different stations of the Ishim River in North Kazakhstan oblast

Reservoir	Stations, 2009				Stations, 2010									
	4	5, 6, 7	8	11	1	2	3	5, 6, 7	8	9	10	12	13	14
Rotifera														
Asplanchna herrickii de Guerne				+				+	+					
Asplanchna priodonta Gosse				+	+			+	+				+	
Brachionus angularis Gosse								+		+	+	+	+	+
Br. calyciflorus anuraeiformis Brehm													+	+
Br. quadridentatus Hermann										+				
Br. quadridentatus brevispinus Ehrenberg								+			+		+	
Br. leydigii leydigii Cohn										+	+		+	+
Cephalodella catellina Müller				+	+	+	+							
Cephalodella gibba gibba (Ehrenberg)											+	+		
Colurella obtusa Gosse					+	+	+	+						
Euchlanis deflexa (Gosse)					+	+	+			+	+	+	+	+
Euchlanis dilatata Ehrenberg			+		+	+	+	+	+		+	+	+	+
Euchlanis incisa Carlin						+								
Filinia longiseta (Ehrenberg)										+		+	+	
Filinia major (Golditz)	+			+							+		+	
Kellicottia longispina (Kellicott)								+	+					
Keratella cochlearis (Gosse)								+	+	+				
Keratella cochlearis tecta (Gosse)								+						
K. quadrata quadrata (Müller)	+	+	+	+	+	+	+	+	+	+	+	+	+	
Lecane luna luna (Müller)					+	+					+		+	+
Lecane ungulata (Gosse)					+									+
Lecane (*Monostila*) *hamata* (Stokes)					+	+	+				+		+	+
Lecane (*M.*) *obtusa* (Murray)						+								
Lepadella ovalis (Müller)											+			+
Mytilina mucronata spinigera (Ehrenberg)											+			
Mytilina ventralis (Ehrenberg)					+	+								
Notommata aurita (Müller)					+									
Polyarthra major Burckhardt											+			
Polyarthra minor Voigt								+	+			+		
Polyarthra remata Skorikov								+	+	+	+		+	+
Synchaeta pectinata Ehrenberg											+			
Testudinella patina patina (Hermann)					+	+	+			+	+			+
Trichocerca capucina (Wierzejski & Zacharias)											+			
Trichocerca cylindrica (Imhof)				+			+	+		+	+			+
Trichocerca (*Diurella*) *bidens* (Lucks)														+

Table 1. (Contd.)

Reservoir	Stations, 2009				Stations, 2010									
	4	5, 6, 7	8	11	1	2	3	5, 6, 7	8	9	10	12	13	14
Trichocerca (*Diurella*) *tenuior* (Gosse)							+							
Trichotria pocillum pocillum (Müller)					+	+								
Trichotria truncata (Whitelegge)											+			
Number of species	2	1	2	6	13	12	9	13	8	10	19	7	13	13
Cladocera														
Acroperus harpae (Baird)				+		+	+			+				
Alona affinis (Leydig)				+	+	+					+	+	+	
Alona rectangula Sars													+	
Alonella nana (Baird)				+										
Bosmina longirostris (O.F. Müller)	+	+	+	+				+	+	+	+	+	+	
Ceriodaphnia affinis Lill.				+					+	+				
Ceriodaphnia quadrangula (O.F. Müller)	+	+	+	+		+	+		+	+		+	+	+
Chydorus ovalis Kurz				+						+				+
Chydorus sphaericus (O.F. Müller)		+		+		+		+	+					+
Daphnia cucullata Sars		+												
Daphnia longispina O.F. Müller	+	+	+	+				+	+			+		
Diaphanosoma brachyurum (Lievin)	+	+	+	+				+	+		+	+		+
Disparalona rostrata (Koch)								+				+		
Graptoleberis testudinaria (Fischer)		+	+	+	+				+			+		
Ilyocryptus acutifrons Sars										+		+	+	
Leydigia leydigii (Leydig)		+										+	+	
Leptodora kindtii (Focke)		+						+						
Macrotrix hirsuticornis Norman	+	+						+				+	+	
Moina rectirostris (Leydig)				+										
Monospilus dispar Sars		+						+				+	+	
Peracantha truncata (O.F. Müller)														+
Pleuroxus aduncus (Jurine)	+		+	+					+					
Pleuroxus (*Picripleuroxus*) *striatus* Schödler				+	+	+	+	+		+	+		+	
Polyphemus pediculus (Linnaeus)				+				+						
Pseudochydorus globosus (Baird)				+										
Scapholeberis mucronata (O.F. Müller)				+						+		+		
Sida crystallina (O.F. Müller)		+		+				+				+		
Simocephalus vetulus (O.F. Müller)				+								+		
Number of species	6	12	6	19	3	5	3	11	8	8	4	14	9	5

Table 1. (Contd.)

Reservoir	Stations, 2009				Stations, 2010									
	4	5, 6, 7	8	11	1	2	3	5, 6, 7	8	9	10	12	13	14
Copepoda														
Diacyclops bicuspidatus (Claus)	+												+	
Cyclops kolensis Lilljeborg	+	+	+	+				+				+		
Cyclops scutifer Sars				+										
Cyclops strenuus strenuus Fischer			+	+										
Cyclops vicinus Uljanin		+												
Macrocyclops albidus (Jurine)								+						
Macrocyclops fuscus (Jurine)				+										
Megacyclops gigas (Claus)								+						
Megacyclops viridis (Jurine)		+						+	+		+	+	+	
Mesocyclops leuckarti Claus	+	+	+	+	+		+	+	+	+	+	+	+	+
Paracyclops fimbriatus (Fischer)		+				+	+			+				
Thermocyclops oithonoides (Sars)	+	+				+		+			+	+	+	+
Thermocyclops crassus (Fischer)									+					
Acanthodiaptomus denticornis (Wierzejski)				+										
Arctodiaptomus dentifer (Smirnov)								+	+					
Eudiaptomus graciloides (Lilljeborg)	+	+	+					+	+		+			
Eudiaptomus gracilis (Sars)				+				+						
Eurytemora affinis (Poppe)												+		
Laophonte mohammed Blanchard & Richard						+	+	+		+		+		
Nitocra hibernica (Brady)					+	+	+	+					+	+
Ergasilus sieboldi Nordmann		+				+		+						
Number of species	5	8	4	7	2	5	4	12	5	3	4	6	4	3
Number of species in the reservoir	**13**	**21**	**12**	**32**	**18**	**22**	**16**	**36**	**21**	**21**	**27**	**27**	**32**	**21**

respectively). An indicator of elevated pollution occurred rather often among *T. oithonoides* Sars. According to long-term observations (Yermolaeva, 2007), the *Cyclops kolensis* in Siberia has two development peaks: the first generation reaches sexual maturity in February to March and the second generation reaches maturity in early June, while adult individuals occur at the end of July. According to the Shannon index (Table 3), a transformed biocenosis dominated by two–three β-mesosaprobic species was observed.

Sergeevskoe Reservoir (stations nos. 5, 6, and 7). Sampling was made in the nearshore areas at depths of up to 1.5 m. The bottom ground is represented by silt loam with sand admixture. The water temperature was 25.6–27.0°C during the research. In 2009, twenty-one zooplankton species were identified, followed by 36 species identified in 2010 (Table 1). Their abundance reached 375160 samples/m^3, and their biomass was 4816.7 mg/m^3 (Table 2). *M. leuckarti* Claus (all development stages), *Brachionus angularis* Gosse, and *D. longispina* Müller) were dominant (13, 28, and 8%, respectively). At some stations, the development of large raptorial *Leptodora kindtii* (Focke) cladocerans was observed (up to 300 samples/m^3). In addition, free-swimming branchial male *Ergasilus sieboldi*, which are parasitic on fish, were found in plankton in all of the studied sections of the reservoir in up to 50–100 samples/m^3, which indicates a high degree of reservoir pollution. The Shannon species diversity index had quite high values ($H > 2.0$) (Table 3). Biocenosis based on β-mesosaprobic eurybiontic forms was observed in the reservoir in all of the studied sections.

Table 2. Abundance (N, individuals/m^3), biomass (B, mg/m^3) and number of species (n) of different zooplankton groups at the Ishim river stations in Northern Kazakhstan oblast

Number of station on the schematic map	Date	N_{total}	B_{total}	Rotifera		Cladocera		Copepoda					
								Calanoida		Cyclopoida		Harpacticoida	
				N	B	N	B	N	B	N	B	N	B
1	05.08.2010	2500	9.7	1840	2.2	80	4.1	0	0.00	560	3.10	20	0.3
2	05.08.2010	3120	22.3	2320	3.3	200	12.1	0	0.00	560	6.20	40	0.7
3	05.08.2010	1300	9.8	700	0.8	80	3.4	0	0.00	360	2.90	160	2.7
4	02.07.2009	87274	4621.3	990	0.4	16764	1115.8	880	96.80	68640	3408.30	0	0.0
5, 6, 7	03.07.2009	3696	94.2	440	0.4	2420	58.2	66	7.30	770	28.30	0	0.0
	03.07.2009	69366	2942.8	25960	21.0	33066	2525.8	220	24.20	10120	371.80	0	0.0
	03.07.2009	15510	6107.8	1760	1.4	6050	5828.6	110	12.10	7590	265.70	0	0.0
	05.08.2010	375160	3150.2	188460	94.4	8980	545.3	80	5.80	177600	2504.00	40	0.7
	05.08.2010	152940	3547.1	63720	31.4	25620	2370.1	6800	489.60	56800	656.00	0	0.0
	05.08.2010	170460	4816.7	46400	214.7	22240	1691.5	14400	1036.80	87200	1870.00	220	3.7
8	04.07.2009	5324	156.60	1210	1.9	286	23.9	110	12.10	3718	118.70	0	0.0
	06.08.2010	74980	856.6	14340	24.6	6580	196.3	1200	86.4	52860	549.30	0	0.0
9	29.07.2010	1220	14.50	580	0.4	360	11.2	0	0.00	260	2.60	20	0.3
10	29.07.2010	10540	42.00	6840	5.1	100	3.5	260	18.70	3340	14.70	0	0.0
11	23.06.2009	46840	1345.50	4430	6.7	19320	307.4	2660	177.70	20430	853.70	0	0
	23.06.2009	33790	1420.20	1562	1.9	21582	968.4	350	38.50	10296	411.40	0	0.0
12	27.07.2010	176740	1179.90	40600	13.7	2240	160.5	120	8.60	133760	996.80	20	0.3
13	27.07.2010	6840	38.50	2860	4.5	360	15.7	0	0.00	3560	17.30	60	1.0
14	27.07.2010	3060	22.30	920	1.4	700	13.4	0	0.00	1360	6.10	80	1.4

Table 3. Coordinates of the Ishim River stations and Pantle-Buck saprobity and Shannon species diversity indices

Number of station on the schematic map	Station GPS coordinates	Pantle-Buck index (S)	Shannon index (H)	Pollution according to the degree of saprobity
1	N 52°21′21″ E 66°40′21″	1.60	1.72	β-mesosaprobity, moderate pollution
2	N 52°56′59″ E 66°37′32″	1.62	1.56	β-mesosaprobity, moderate pollution
3	N 53°20′49″ E 66°59′25″	1.60	1.69	β-mesosaprobity, moderate pollution
4	N 53°24′55″ E 67°03′47″	1.66	1.56	β-mesosaprobity, moderate pollution
5	N 53°31′47″ E 67°05′39″	1.52	2.04	β-mesosaprobity, moderate pollution
6	N 53°39′80″ E 67°12′06″	1.53	2.19	β-mesosaprobity, moderate pollution
7	N 53°51′03″ E 67°24′23″	1.55	2.25	β-mesosaprobity, moderate pollution
8	N 55°90′43″ E 69°15′47″	1.60	1.61	β-mesosaprobity, moderate pollution
9	N 54°15′27″ E 68°13′51″	1.61	1.59	β-mesosaprobity, moderate pollution
10	N 54°41′50″ E 68°58′42″	1.65	2.42	β-mesosaprobity, moderate pollution
11	N 54°52′35″ E 69°03′49″	1.58	2.44	β-mesosaprobity, moderate pollution
12	N 54°56′05″ E 69°07′06″	1.66	1.99	β-mesosaprobity, moderate pollution
13	N 55°03′04″ E 69°08′39″	1.67	2.16	β-mesosaprobity, moderate pollution
14	N 55°22′30″ E 69°22′48″	1.59	2.46	β-mesosaprobity, moderate pollution

In separate sections, subdominants included stenobiontic phytophilous forms: *Colurella obtusa* Gosse, *Disparalona rostrata* (Koch), *Macrotrix hirsuticornis* Norman, and *Sida crystallina* (O. F. Müller)).

Ishim River downstream of the Sergeevskoe Reservoir (station no. 8). The depth was 4.7 m. The water temperature was 22.2°C. The bottom is covered with silty crushed stone and coarse sand. Twenty-one zooplankton species were identified. Their abundance and biomass were significantly higher than those in the river upstream of the reservoir (Table 2). The majority of the community was represented by *M. leuckarti* Claus (41% of the total abundance, all development stages), adult individuals without egg pouches, and *Cyclops strenuus* Fisch (25%), and *K. quadrata* (Müller)) copepodites of the third and fourth stages (12%). Despite the influence of the upper reservoir, a transformed biocenosis dominated by 2–3 β-mesosaprobic species was observed in this section. The Shannon species diversity index was low (Table 3).

Upstream Yesil'skoe village (station no. 9). The bottom ground was muddy, with admixed clay and sand. The depth was 0.8 m. The temperature was 21.4°C. Twenty-one species were recorded in zooplankton. The quantitative indicators were very low (Table 2). The abundance was dominated by *M. leuckarti* Claus nauplii (18%) and *Filinia major* (Golditz) copepodites of the second and third stage (18%). With respect to the Pantle-Buck saprobity index, the river section can be characterized as β-mesosaprobic. The Shannon index (Table 3) characterizes the community as a transformed one. Some rare stenobiontic planktobenthic and neustonic species, such as *Paracyclops fimbriatus* (Fischer), *Ilyocryptus acutifrons* Sars, and *Scapholeberis mucronata* (O.F. Müller)) were marked.

35 km upstream of the city of Petropavlovsk (station no. 10). The bottom has silt with admixed sand. The depth at the station did not exceed 0.75 m. The temperature was 22.4°C. Twenty-seven species were marked in the zooplankton community (Table 1), including many phytophilous species. The quantitative indicators were low (Table 2). *M. leuckarti* Claus nauplii and copepodites of the second to fourth stages and *Polyarthra remata* Skorikov and *F. major* (Golditz) rotifers were dominant in abundance (30, 15, and 15%, respectively). The high Shannon index indicates that a multispecies biocenosis was formed in this section. The basic representatives of the community were β-mesosaprobic eurybiontic forms, with phytophilous rotifer species having made significant progress in their development: *Lecane* (*Monostila*) *hamata* (Stokes), *Mytilina mucronata spinigera* (Ehrenberg), and *Trichotria truncata* (Whitelegge) (Table 3).

In the vicinity of the city of Petropavlovsk (station no. 11, Petropavlovskoe reservoir). Sampling was made in sections with a depth of up to 1.5 m. The water temperature was 24.9–25.2°C during the research. The bottom has clay with sand admixture; on separate sections, the silt has hydrogen-sulfide flavor. Thirty-two species were recorded, including many phytophilous Cladocera, which are characteristic of lakes and water reservoirs. There are only six rotifer species. The development of zooplankton is quite significant for the river ecosystem (Table 2). Large cyclopes prevailed in quantitative terms. Separate sites were dominated by adult *Cyclops scutifer* Sars individuals (up to 27% of the total abundance), *Acanthodiaptomus denticornis* Wierz. (up to 3%), *Bosmina longirostris* (Müller)) (up to 36%), *Ceriodaphnia quadrangula* (Müller)) (up to 39%), and *K. quadrata* (Müller)) (3–7%), i.e., by eurybiontic β-mesosaprobic and α-β-mesosaprobic forms. Note that *C. scutifer* was previously considered to be a cold-water species. However, females with egg pouches frequently occurred in our samples in the water reservoirs in the south of western Siberia in June, though as a rule there are usually few fry of this species in samples taken in the summer (Yermolaeva, 2007). A significant number of stenobiontic phytophilous Cladocera, such as *D. rostrata*, *Graptoleberis testudinaria* (Fischer), *M. hirsuticornis*, *S, crystallina*, and *Simocephalus vetulus* (O. F. Müller), was also marked (Table 1). The community is multispecies; therefore, the Shannon diversity index is high (Table 3).

Downstream of the city of Petropavlovsk, near the village of Borki (station no. 12). The river overflows in stretches. The depth was 0.9 m. The temperature was 22.2°C. The bottom ground is sand and silty. Twenty-seven zooplankton species were marked. Cladocera prevailed in qualitative terms, including stenobiontic forms (e.g., *Ilyocryptus acutifrons* Sars, *Leydigia leydigii* (Leydig), *Monospilus dispar* Sars, and *S. mucronata*). Due to the influence of the upper reservoir, the quantitative indicators are quite high (Table 2). The abundance was dominated by Copepodites of the fourth to fifth stages and *M. leuckarti* Claus nauplii (60%), *F. major* (Golditz) rotifers (4%), and *P. remata* Skorikov (16%), i.e., by β-mesosaprobic forms. Based on the Shannon index (Table 3), zooplankton cenosis occurs under quite favorable conditions.

Upstream of the village of Bol'shaya Malyshka (station no. 13). Ripple. The depth was 0.8 m. The temperature was 21.4°C. The bottom ground is coarse grained and sandy. Thirty-two zooplankton species were identified. Rotifera prevailed in qualitative terms. Rotifera and Cyclopoida nauplii were the basis of the abundance, and biomass was provided by large Cladocera and adult Cyclopoida (Table 2). β-mesosaprobic eurybiontic *Brachionus calyciflorus calyciflorus* Pallas and *M. leuckarti* Claus were dominant in abundance (17% and 24%, respectively). The subdominate was *T. oithonoides* Sars (12%), which was an elevated pollution indicator (Yermolaeva and Dvurechenskaya, 2013, 2014a). According to the Shannon index value (Table 3), a non-transformed multispecies biocenosis was observed at the given station.

Near the village of Krasnyi Yar (station no. 14). The depth was 0.7 m. The temperature was 22.2°C. The bottom has silt with loam admixture and macrophyte detritus. Twenty-one species were identified in zooplankton. Rotifers prevailed with respect to species diversity. The abundance and biomass were comparable with the indicators at the 13th station (Table 2). The abundance was dominated by β-mesosaprobic *M. leuckarti* Claus eurybionts (39% of the total abundance, all development stages) and *Chydorus sphaericus* eurybionts (Müller)) (15%). Representatives of the phytophilous complex were marked: *Lecane ungulata* (Gosse), *Lepadella ovalis* (Müller), and *Peracantha truncata* (O. F. Müller)). The biocenosis is multispecies at this station and is based on eurybiontic forms; the Shannon index is quite high (Table 3).

DISCUSSION

According to Pil'guk and Zholsbolsynova (1981), 86 zooplankton species were identified in the zooplankton of Ishim on the territory of North Kazakhstan oblast. Our data on the species wealth of zooplankton and the assessment of water quality according to its indicators are close to those provided in this work. The species composition of zooplankton in the middle reaches of the Ishim in North Kazakhstan oblast is similar to that in the lower reaches of the river (Aleshina et al., 2009) and other lowland rivers in the south of Western Siberia (Yermolaeva, 2010; Kukharskaya, 2011). The largest species diversity was marked among rotifers, which is generally characteristic of the river zooplankton (Krylov, 2005).

The river in North Kazakhstan oblast undergoes contaminations that generally include domestic wastes. So far, the stream biota can endure contaminants by reacting to them; however, this reaction comes in the form of a disturbance of the biocenosis structure. The reduction in the value of the Shannon index (H) on separate sections shows that the structure of the community is less homogeneous and the predominance of separate elements increases. In other words, structural simplification takes place. On the contrary, an increase in the index (H) value is characteristic of an increase in the uncertainty and homogeneity of the structure of the studied system and indicates more favorable conditions in the community, under which the species diversity is high and the level of the development of each species is equivalent (Alimov, 2000). The higher the species diversity and species wealth of the system is, the more difficult is to change its state and the more sustainable is the system, since different species in the system functionally supplement and replace each other through complex trophic, topic, and other relations.

Many researchers associate the complexity of the structure of biotic communities, as assessed by their species diversity, with their stability: the more diverse the system is, the more it is sustainable (Margalef, 1968; MacArthur, 1955; Voris et al., 1980). Under the influence of anthropogenic factors during water reservoir eutrophication, the diversity and stability of systems decrease. In oligotrophic water reservoirs, the diversity of communities is high, and the predominance of separate species is less pronounced than that inherent in eutrophic species, which are distinguished by lesser species diversity (Margalef, 1964; Reed, 1978). When a water reservoir has a natural development, stability in the species composition of zooplankton communities for tens and even hundreds of years is observed (Andronnikova, 1996). The most sustainable are communities and ecosystems with a higher species diversity in which stenobiontic species prevail (Alimov, 1989). The number of dominant species (with a relative density or biomass of more than 5%) in stable ecosystems is from 4 to 5 (Alimov, 2000). During eutrophication, the composition and structure of dominant zooplankton complexes are significantly transformed; mono- or bidominant communities are formed, in which 1 to 2 species form the majority of the abundance and biomass (Andronikova, 1996; Makartseva, 1986; Ivanova, 1997).

At the studied river stations, the (H) index varies from 1.56 to 2.46. The most complicated structure of the community and, hence, the most sustainable zooplankton complexes are marked in the sections of the Sergeevskoe and Petropavlovskoe reservoirs. Change takes place in the hydrological regime of the river in water reservoirs, which results in a sharp slowdown of currents and changes in the morphometry, as well as in the seasonal and circadian dynamics of intrareservoir processes associated with the effect of physical and chemical (temperature, sorption and desorption processes, sedimentation processes, leaching, etc.) factors (Bolgov et al., 2008). Biological indicators (abundance and species composition of hydrobionts, their migration, functioning, etc.) change (Yermolaeva and Dvurechenskaya, 2007, 2014b).

Downstream of the river, from station no. 1 to station no. 14, the values of the Shannon index increased, which may indicate the formation of a more sustainable structure of the zooplankton community and some degree of restoration of the river ecosystem downstream of the city of Petropavlovsk. The description of the species and quantitative composition of the Ishim zooplankton in Tyumen oblast (Aleshina et al., 2009) generally coincides with our data obtained in profiles nos. 13 and 14 downstream of the Petropavlovskoe reservoir.

To assess the overall level of pollution of different watercourse segments, the Pantle-Buck saprobity index was estimated; its indicators are given in Table 3. The value of the index at different stations of the Ishim River varied from 1.52 to 1.67. The obtained values correspond to the "β-mesosaprobic zone." According to the integrated ecological classification of quality of inland surface waters, the saprobity index corresponds to the third water quality class, i.e., the water of "satisfactory purity," and to category 3a, i.e., "quite pure water" (Oksiyuk et al., 1993).

When comparing the value of the Pantle-Buck index at different stations, one should note again that the lowest index values and, hence, a higher water quality with respect to the saprobity indices, are found in the regulated sections. Water reservoirs have a purifying effect on water quality with respect to a number of indicators, such as the concentrations of total nitrogen, nitrates, nitrite, total phosphorus, and suspended sediments, as well as total suspended solids, etc. (Morris et al, 2014; Huang et al, 2014; Savkin and Dvurechenskaya, 2014).

Upstream of the river in the area of the city of Astana, 75 zooplankton species were identified in 2004–2009, which may be due to the longer observation period (Akbaeva et al., 2012). The Pantle-Buck index modified by Slàdeček varied from 1.5 to 1.6 in the given section, which allows one to relate the Ishim waters in this section to β-mesosaprobic ones. In the lower reaches of the river in Tyumen oblast, the index values varied from 1.5 to 1.8 (Aleshina et al., 2009). That is, the quality class of the Ishim water according to saprobic indicators estimated with respect to zooplankton remain almost unchanged downstream.

At the present time, assessment of the general river condition shows that it is satisfactory with respect to hydrochemical indicators, while it is obviously adverse with respect to hydrobiological indicators. One may note that the general nature of the river pollution has been almost unchanged since 1973 (Pil'guk, 1973). At most of the studied stations, the zooplanktonic biocenosis is transformed. The communities are largely mono- and bidominant, which characterizes them as very unsustainable. However, there are also sections with undisturbed biocenosis. This shows that the potential for river self-regeneration and self-purification has not been completely destroyed and it is possible to restore the river ecosystem by environmental protection measures. The regulated sections of the river can be refugiums that provide separate zooplankton species to the watercourse ecosystem. However, there is a danger that, in the case of insufficient purification of watercourses in the area of the city of Astana, an accumulation of polluting substances will take place exactly in the water reservoir areas, which may lead to degradation of the river ecosystem of the middle and lower reaches of the Ishim in general.

CONCLUSIONS

The major zooplankton abundance and biomass in unregulated sections are formed primarily by Cyclopoida nauplii and copepodites, while the water reservoirs and the lower reaches of the river downstream of Petropavlovsk are dominated by Cladocera.

At the moment, the zooplankton community is transformed at most of the studied stations: it normally has a simplified mono- or bidominant structure. However, the potential for the river self-regeneration and self-purification has not been completely destroyed, which is evidenced by a sufficiently high species diversity, and the river ecosystem can be regenerated by environmental protection measures.

A separate danger for the fish industry is represented by the high degree of contamination of some sections of the Ishim River (especially the water areas of the Sergeevskoe reservoir) with *Ergasilus sieboldi* Nordmann parasites.

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