IRSTI 34.35.33 https://doi.org/10.26577/eb.2024.v99.i2.09

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CHARACTERISTICS OF THE MODERN TAXONOMIC COMPOSITION OF THE PHYTOPLANKTON IN THE KAZAKHSTAN PART OF THE IRTYSH RIVER

The transboundary Irtysh River flows through the territory of three countries. The Irtysh River is subjected to intense anthropogenic impact. In the Kazakhstan part of the Irtysh River basin, there are zones of industrial influence in the cities of Pavlodar and Aksu. Hydroelectric power, ferroalloy plants, and coal pits are located in the territory of these cities. The study of the species composition of phytoplankton is a basic method in bioindication. Phytoplankton plays an essential role in evaluating the ecological status of aquatic ecosystems. The algae flora of the transboundary Irtysh River has not been studied thoroughly enough. Most hydrobiological studies in the Kazakhstan part of the Irtysh River basin were devoted to studying reservoirs. Based on this, the relevance of studying the planktonic communities of the Kazakhstan part of the Irtysh River is increasing. This study aimed to analyze the richness of phytoplankton species in the Kazakh part of the Irtysh River basin. The research was conducted in July 2023 at 27 stations. The selection sites were located on the upper and lower reaches of the Irtysh River. Sections of the Black Irtysh, from the border with the Altai to the confluence with Lake Zaisan, and sections in the Pavlodar region were surveyed. We registered 153 species and subspecies of algae from Heterokontophyta (69), Chlorophyta (61), Cyanobacteria (16), Charophyta (4), Euglenophyta (2), and Dinoflagellata (1) in the phytoplankton. A high level of similarity characterized phytoplankton of most of the surveyed sites.

Key words: phytoplankton, taxonomic composition, taxonomic similarity, genus, species, Irtysh River.

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Ертіс өзенінің қазақстандық бөлігіндегі фитопланктонның қазіргі таксономиялық құрамының сипаттамасы

Трансшекаралық Ертіс өзені үш мемлекеттің аумағы арқылы өтеді. Ертіс өзені қарқынды антропогендік әсерге ұшырайды. Ертіс өзені бассейнінің қазақстандық бөлігінде Павлодар және Ақсу қалаларының өндірістік әсер ету аймақтары бар. Бұл қалалардың аумағында су электр станциялары, көмір шахталары және ферроқорытпа зауыттары орналасқан. Планктондық қауымдастықтардың түр құрамын зерттеу биоиндикацияның іргелі әдісі болып табылады. Фитопланктон су экожүйелерінің экологиялық жағдайын бағалауда маңызды рөл атқарады. Трансшекаралық Ертіс өзенінің балдырлар флорасы толық зерттелмеген. Ертіс өзені бассейнінің қазақстандық бөлігіндегі гидробиологиялық зерттеулердің көпшілігі су қоймаларын зерттеуге арналған. Осыған байланысты, Ертіс өзенінің қазақстандық бөлігіндегі планктондар қауымдастығын зерттеудің өзектілігі артуда. Бұл зерттеудің мақсаты – Ертіс өзені бассейнінің қазақстандық бөлігіндегі фитопланктонның түрлік байлығын талдау. Зерттеулер 2023 жылдың шілде айында 27 станцияда жүргізілді. Сынама алу орындары Ертіс өзенінің жоғарғы және төменгі ағысында орналасқан. Қара Ертістің Қытаймен шекарасынан Зайсан көліне құярға дейінгі учаскелері, сондай-ақ Павлодар облысындағы учаскелері зерттелді. Фитопланктон құрамында 153 түрлер мен түршелері тіркелді, атап айтқанда гетероконттар – Heterokontophyta (69), жасыл балдырлар – Chlorophyta (61), цианобактериялар – Cyanobac-

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teria (16), харалар – Charophyta (4), эвгленалар – Euglena (2) және динофитті балдырлар – Dinoflagellata (1). Алаптың зерттелген аумақтарының көпшілігінің фитопланктондары ұқсастық деңгейінің жоғарылығымен сипатталды.
Түйін сөздер: фитопланктон, таксономиялық құрамы, таксономиялық ұқсастық, тұқымдас, түр, Ертіс өзені.

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Характеристика современного таксономического состава фитопланктона казахстанской части реки Иртыш

Трансграничная река Иртыш протекает по территории трех государств. Река Иртыш подвергается интенсивному антропогенному воздействию. На казахстанской части бассейна реки Иртыш есть зоны промышленного влияния городов Павлодар и Аксу. На территории этих городов расположены гидроэлектростанции, угольные карьеры и заводы ферросплавов. Изучение видового состава планктонных сообществ является фундаментальным методом биоиндикации. Фитопланктон играет существенную роль в оценке экологического состояния водных экосистем. Альгофлора трансграничной реки Иртыш изучена недостаточно полно. Большинство гидробиологических исследований на казахстанской части бассейна реки Иртыш было посвящено изучению водохранилищ. Исходя из этого актуальность изучения планктонных сообществ казахстанской части реки Иртыш возрастает. Целью настоящего исследования был анализ видового богатства фитопланктона казахстанской части бассейна реки Иртыш. Исследования были проведены в июле 2023 года на 27 станциях. Места отбора располагались на верхнем и нижнем течении реки Иртыш. Были обследованы участки Черного Иртыша, от границы с Китаем до впадения в озеро Зайсан, а также участки в Павлодарской области. В составе фитопланктона было зарегистрировано 153 вида и подвида водорослей из отделов гетероконты – Heterokontophyta (69), зеленые – Chlorophyta (61), цианобактерии – Cyanobacteria (16), харовые – Charophyta (4), эвгленовые – Euglenophyta (2), и динофлагелляты – Dinoflagellata (1). Фитопланктон большей части обследованных участков бассейна характеризовался высоким уровнем сходства.
Ключевые слова: фитопланктон, таксономический состав, таксономическое сходство, род, вид, река Иртыш.

Introduction

The study of phytoplankton in transboundary rivers is essential for assessing water quality. Bioindication is a fundamental technique to evaluate water quality. Algae, most of which are autotrophs, form the basis of a trophic chain in an aquatic ecosystem. Phytoplankton, using biogenic nitrogen and phosphorus compounds, participates in producing organic substances. The biogenic load's intensity impacts plankton communities' development and their species richness. Therefore, indicators of abundance, biomass and species composition are used in bioindication methods. A significant link in bioindication is the study of the species composition of phytoplankton communities [1]. Phytoplankton is a crucial element of the trophic chain of aquatic ecosystems and is important as a food base for fish and planktonic invertebrates.

The length of the Irtysh River is 4248 km. Its length is 1,700 km on the territory of Kazakhstan. The Irtysh River is a water source for agriculture, industry, and the population [2].

The study of phytoplankton in the Irtysh River was started in the 60s of the last century [3-5]. According to available data, the species richness of phytoplankton of the middle and lower parts of the Irtysh River varied from 158 to 211 species from 9 departments [6]. Hydroelectric power stations are located along the upper reaches of the Irtysh River: Bukhtarminskaya, Ust-Kamenogorsk and Shulbinskaya. Many phytoplankton studies in the Kazakh river basin have been conducted at the Bukhtarminskoye and Shulbinskoye reservoirs [7-11]. In the algae flora of the upper Irtysh, 8 divisions, 13 classes, 22 orders, 56 families, 347 species and 401 varieties and forms of algae were noted [12-19]. Two hundred forty-nine species have been recorded, including 73 new species not previously found in the Bukhtarma reservoir and 176 new species in the middle Irtysh.

The study of phytoplankton communities in the Irtysh River basin is multidirectional due to its large geographical extent. Most of the studies were conducted in the Russian territory of the Irtysh River basin. The phytoplankton of the Kazakhstan part of the Irtysh River has not been studied thoroughly enough. In this regard, the relevance of the study of this site for the analysis and further assessment of water quality arises.

The study aims to analyze the species richness and distribution of phytoplankton in the upper and lower reaches of the Kazakhstan part of the Irtysh River basin.

Materials and methods

The study of the Kazakhstan part of the Irtysh River was conducted in July 2023 at 27 stations in 4 sections (Figure 1).

Section I covered the Black Irtysh, from the border with China to its confluence with Lake Zaisan (5 stations). Section II was located above the cities of Pavlodar and Aksu (7 stations). The following section combined five stations located in the zone of influence of the Pavlodar and Aksu cities. Section IV was located below the city of Pavlodar (10 stations). Coordinates, water transparency, temperature and pH were recorded at the sampling stations.

Phytoplankton samples were taken from the surface layers by stretching and scooping 1 litre of water [20]. Water samples were fixed with 40% formalin. After the phytoplankton deposition, the samples were brought to a volume of 30 ml, and with a high density of the green film on the surface of the water, up to 100 ml. At this stage, before quantitative analysis, phytoplankton samples were examined under a microscope to determine the species composition. Next step, a thick drop of sediment from the bottom of the vial was taken from the total sample. Determinants were used to identify species and their systematic classification [21-29]. The abundance of planktonic algae was estimated on a six-point scale [30]. The numerical values correspond to the designations, where 1 is single, 2 is rare, 3 is not rare, 4 is common, 5 is very common, and 6 is massive, according to the Corde method [31]. Due to the large tabular material, it was decided to divide the data into four selection sites. The JASP statistical program was used for comparative analysis of phytoplankton communities [32]. Changes in the modern systematics of algae were tracked using the AlgaeBase database of marine and freshwater algae [33].

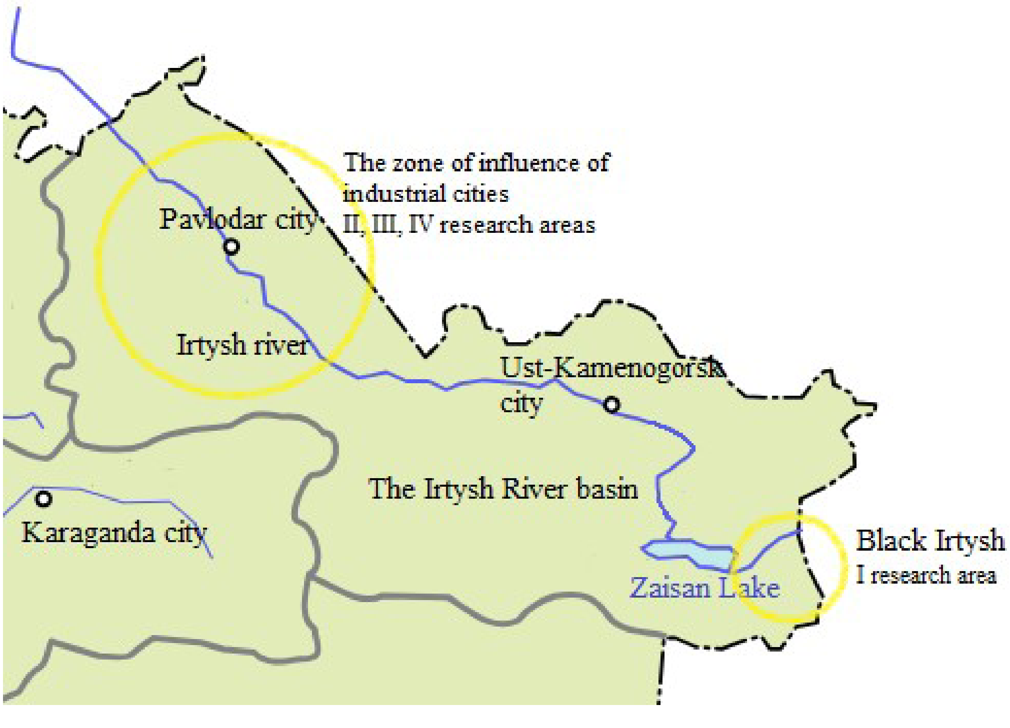

Figure 1 – Research areas in the Kazakh part of the Irtysh River basin in July 2023

Results and Discussion

One hundred fifty-three species belonging to 86 genera and 6 phyla have been found in the river phytoplankton. The genera *Desmodesmus* (12 species), *Nitzschia* (9 species), *Scenedesmus* (8 species) and *Navicula* (6 species) were characterized by the most species richness (Table 1).

Table 1 – The species composition of phytoplankton in the Kazakhstan part of the Irtysh River (July 2023)

Taxa	I	II	III	IV
Heterokontophyta				
Amphora pediculus (Kützing) Grunow 1875	+			
Amphora ovalis (Kützing) Kützing 1844	+			
Asterionella formosa Hassall, 1850	+	+	+	+
Aulacoseira distans (Ehrenberg) Simonsen 1979	+			
Aulacoseira granulata (Ehrenberg) Simonsen 1979	+	+	+	+
Aulacoseira italica (Ehrenberg) Simonsen 1979	+			
Cocconeis placentula Ehrenberg 1838	+	+	+	+
Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin 1964	+			
Cymbella affinis Kützing 1844	+			
Cymbella cistula (Ehrenberg) O.Kirchner 1878	+		+	
Cymbella tumida (Brébisson) Van Heurck 1880				+
Cymbella turgidula Grunow 1875	+	+	+	
Cymbopleura naviculiformis (Auerswald ex Heiberg) Krammer 2003	+			
Diatoma vulgaris Bory 1824	+	+	+	+
Didymosphenia geminate (Lyngbye) Mart.Schmidt 1899	+			
Dinobryon divergens O.E.Imhof 1887	+			
Diploneis ovalis (Hilse) Cleve 1891	+			
Diploneis parma Cleve 1891	+			
Encyonema elginense (Krammer) D.G.Mann 1990			+	
Encyonema minutum (Hilse) D.G.Mann 1990	+	+		+
Encyonema ventricosum (C.Agardh) Grunow 1875	+			
Epithemia adnata (Kützing) Brébisson 1838				+
Pinnularia viridis (Nitzsch) Ehrenberg 1843	+			
Fragilaria capucina Desmazières 1830	+	+		
Fragilaria crotonensis Kitton 1869	+	+	+	+
Fragilaria rumpens (Kützing) G.W.F.Carlson 1913	+			
Fragilariforma constricta (Ehrenberg) D.M.Williams & Round 1988	+			
Fragilariforma virescens (Ralfs) D.M.Williams & Round 1988		+		
Gomphonella olivacea (Hornemann) Rabenhorst 1853	+	+	+	+
Gomphonema parvulum (Kützing) Kützing 1849	+			

Table continuation

Taxa	I	II	III	IV
Gomphonema micropus Kützing 1844	+			
Gyrosigma acuminatum (Kützing) Rabenhorst 1853			+	
Hannaea arcus (Ehrenberg) R.M.Patrick 1966	+			
Iconella biseriata (Brébisson) Ruck & Nakov 2016				+
Navicula exigua W.Gregory, 1854	+			
Navicula recens (Lange-Bertalot) Lange-Bertalot 1985	+			
Navicula rhynchocephala Kützing 1844		+		+
Navicula cryptocephala Kützing 1844	+			
Navicula radiosa Kützing 1844		+		+
Navicula rostellata Kützing 1844		+		
Navicymbula pusilla (Grunow) Krammer 2003	+			
Neidium ampliatum (Ehrenberg) Krammer 1985		+		
Neidium iridis (Ehrenberg) Cleve 1894				+
Nitzschia acicularis (Kützing) W.Smith, 1853	+	+	+	+
Nitzschia filiformis (W.Smith) Van Heurck 1896				+
Nitzschia fonticola (Grunow) Grunow 1881				+
Nitzschia linearis W.Smith 1853	+		+	+
Nitzschia perminuta Grunow 1881				+
Nitzschia dissipata (Kützing) Rabenhorst 1860	+			
Nitzschia longissima (Brébisson ex Kützing) Grunow 1862				+
Nitzschia palea (Kützing) W.Smith 1856	+		+	+
Nitzschia vermicularis (Kützing) Hantzsch 1860				+
Odontidium hyemale (Roth) Kützing 1844	+			
Placoneis elginensis (W.Gregory) E.J.Cox 1988		+		
Reimeria sinuata (W.Gregory) Kociolek & Stoermer 1987	+	+		
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot 1980		+		
*Rhopalodia gibba (*Ehrenberg) O.Müller 1895	+			
Pseudokephyrion poculum W.Conrad 1939	+	+		
Sellaphora pupula (Kützing) Mereschkovsky 1902	+		+	+
Stephanocyclus meneghinianus (Kützing) Kulikovskiy, Genkal & Kociolek 2022	+	+	+	+
Stephanodiscus hantzschii Grunow 1880	+	+		+
Surirella angusta Kützing 1844				+
Surirella librile (Ehrenberg) Ehrenberg 1845				+
Surirella minuta Brébisson ex Kützing, nom. illeg. 1849				+
Tryblionella hantzschiana Grunow 1862	+			

Table continuation

Taxa	I	II	III	IV
Tryblionella scalaris (Ehrenberg) Siver & P.B.Hamilton 2005	+			
Ulnaria danica (Kützing) Compère & Bukhtiyarova 2006		+	+	+
Ulnaria goulardii (Brébisson ex Cleve & Grunow) D.M.Williams, Potapova & C.E.Wetzel 2022	+			
Ulnaria ulna (Nitzsch) Compère 2001	+	+		
Charophyta				
Cosmarium punctulatum Brébisson 1856		+	+	+
Hyalotheca dissiliens Brébisson ex Ralfs 1848	+			
Staurastrum cingulum (West & G.S.West) G.M.Smith 1922				+
Staurastrum gracile Ralfs ex Ralfs 1848			+	+
Chlorophyta				
Actinastrum hantzschii Lagerheim 1882	+			+
Ankistrodesmus arcuatus Korshikov 1953	+	+	+	+
Ankistrodesmus fusiformis Corda 1838	+	+	+	
Ankyra ancora (G.M.Smith) Fott 1957	+			
Chlorotetraedron incus (Teiling) Komárek & Kovácik 1985				+
Coelastrum astroideum De Notaris 1867	+	+		
Coelastrum microporum Nägeli 1855			+	
Coelastrum pulchrum Schmidle 1892			+	
Coenochloris pyrenoidosa Korshikov 1953	+			
Comasiella arcuate (Lemmermann) E.Hegewald, M.Wolf, Al.Keller, Friedl & Krienitz 2010	+		+	
Desmodesmus abundans (Kirchner) E.H.Hegewald 2000	+	+		
Desmodesmus armatus (Chodat) E.H.Hegewald 2000		+	+	+
Desmodesmus brasiliensis (Bohlin) E.Hegewald 2000		+	+	+
Desmodesmus caudatoaculeatus(Chodat) P.M.Tsarenko 2000		+	+	+
Desmodesmus communis (E.Hegewald) E.Hegewald 2000	+	+		
Desmodesmus costatogranulatus (Skuja) E.Hegewald 2000	+			
Desmodesmus intermedius (Chodat) E.Hegewald 2000		+		
Desmodesmus magnus (Meyen) P.M.Tsarenko 2000			+	+
Desmodesmus multicauda (Masjuk) P.M.Tsarenko 2000		+		
Desmodesmus serrato-pectinatus (Chodat) P.M.Tsarenko 2000			+	
Desmodesmus spinosus (Chodat) E.Hegewald 2000				+
Desmodesmus subspicatus (Chodat) E.Hegewald & A.W.F.Schmidt 2000		+		
Eudorina elegans Ehrenberg 1832	+			+
Golenkiniopsis solitaria (Korshikov) Korshikov 1953	+			
Granulocystopsis decorata (Svirenko) P.M.Tsarenko 2000				+

Table continuation

Taxa	I	II	III	IV
Hegewaldia parvula (Woronichin) Pröschold, C.Bock, W.Luo & L Krienitz 2010				+
Heleochloris pallida Korshikov 1953	+	+		
Messastrum gracile (Reinsch) T.S.Garcia 2021	+			
Micractinium pusillum Fresenius 1858	+	+		
Micractinium quadrisetum (Lemmermann) G.M.Smith 1916		+		
Monoraphidium griffithii (Berkeley) Komárková-Legnerová 1969	+	+	+	+
Monoraphidium contortum (Thuret) Komárková-Legnerová 1969	+	+	+	+
Monoraphidium minutum (Nägeli) Komárková-Legnerová 1969	+	+		+
Mucidosphaerium pulchellum (H.C.Wood) C.Bock, Proschold & Krienitz 2011	+	+	+	+
Mychonastes jurisii (Hindák) Krienitz, C.Bock, Dadheech & Proschold 2011			+	
Oocystis borgei J.W.Snow 1903			+	
Oocystis elliptica West 1892				+
Oocystis submarina Lagerheim 1886		+		+
Paradoxia multiseta Svirenko 1928			+	
Pediastrum duplex Meyen 1829	+	+	+	+
Pseudopediastrum boryanum (Turpin) E.Hegewald 2005		+		+
Raphidocelis sigmoidea Hindák 1977	+	+	+	+
Raphidocelis danubiana (Hindák) Marvan, Komárek & Comas 1984		+		
Scenedesmus apiculatus Corda 1838	+			
Scenedesmus circumfusus Hortobágyi 1960		+		+
Scenedesmus ellipticus Corda 1835		+	+	+
Scenedesmus intermedius var.*acutispinus* (Y.V.Roll) E.Hegwald & An 1998				+
Scenedesmus obtusus Meyen 1829				+
Scenedesmus semicristatus Uherkovich 1966				+
Scenedesmus semipulcher Hortobágyi 1960	+	+		
Scenedesmus soli Hortobágyi 1960	+			+
Sphaerocystis planctonica (Korshikov) Bourrelly 1974	+	+	+	+
Stauridium tetras (Ehrenberg) E.Hegewald 2005				+
Tetradesmus incrassatulus (Bohlin) M.J.Wynne 2016	+	+	+	+
Tetradesmus lagerheimii M.J.Wynne & Guiry 2016	+	+	+	+
Tetradesmus obliquus (Turpin) M.J.Wynne 2016	+	+		
Tetraëdron minimum (A.Braun) Hansgirg 1889				+
Tetraspora imperfecta Korshikov 1953			+	+

Table continuation

Taxa	I	II	III	IV
Tetrastrum elegans Playfair 1917		+		
Tetrastrum staurogeniiforme (Schröder) Lemmermann 1900	+			
Willea apiculate (Lemmermann) D.M.John, M.J.Wynne & P.M.Tsarenko 2014			+	+
Cyanobacteria				
Anathece clathrate (West & G.S.West) Komárek, Kastovsky & Jezberová 2011		+		
Aphanizomenon flos-aquae Ralfs ex Bornet & Flahault 1886	+			
Aphanocapsa delicatissima West & G.S.West 1912				+
Aphanocapsa planctonica (G.M. Smith) Komárek & Anagnostidis 1995				+
Aphanocapsa elachista West & G.S.West 1894				+
Aphanocapsa incerta (Lemmermann) G.Cronberg & Komárek 1994	+			
Aphanothece salina Elenkin & A.N.Danilov 1915		+		
Chroococcus minutus (Kützing) Nägeli 1849	+			
Gloeobacter violaceus Rippka, J.B.Waterbury & Cohen-Bazire, nom. cons. 1974		+		
Heteroleibleinia kuetzingii (Schmidle) Compère 1985				+
Limnothrix redekei (Goor) Meffert 1988	+		+	
Merismopedia minima G.Beck 1897	+	+		
Merismopedia tenuissima Lemmermann 1898	+			
Microcoleus autumnalis (Gomont) Strunecky, Komárek & J.R.Johansen 2013		+		
Microcystis aeruginosa (Kützing) Kützing 1846				+
Synechocystis planctonica Proskina-Lavrenko 1951	+			
Euglenophyta				
Lepocinclis oxyuris (Schmarda) B.Marin & Melkonian 2003		+		
Trachelomonas hispida (Perty) F.Stein 1878	+			
Dinoflagellata				
Peridiniopsis quadridens (F.Stein) Bourrelly 1968	+	+		
Total:	86	62	44	69
Sites: I – The Black Irtysh, from the border with China to its confluence with Lake Zaisan, II – above the city of Aksu, III – in the zone of influence of the cities of Pavlodar and Aksu, IV – below the city of Pavlodar				

The species richness decreased in the direction from site I to site III and then increased again in the lowest reaches of the Kazakhstan part of the Irtysh River basin.

Sixteen species of diatoms and green algae were found everywhere: *Asterionella formosa, Aulacoseira granulata, Cocconeis placentula, Fragilaria crotonensis, Gomphonella olivacea, Nitzschia acicularis, Stephanocyclus meneghinianus, Ankistrodesmus arcuatus, Monoraphidium griffithii, M. contortum, Mucidosphaerium pulchellum, Pediastrum duplex, Raphidocelis sigmoidea, Sphaerocystis planctonica, Tetradesmus incrassatulus, T. lagerheimii.*

Each site has a different species composition of planktonic communities. Forty-two unique species have been identified in the Black Irtysh. In the zone of influence of the cities of Pavlodar and Aksu, 12 and 6 new species were identified at sites II and III, respectively. In the lower reaches of the Irtysh River, the species richness increased again to 24 species (Figure 2).

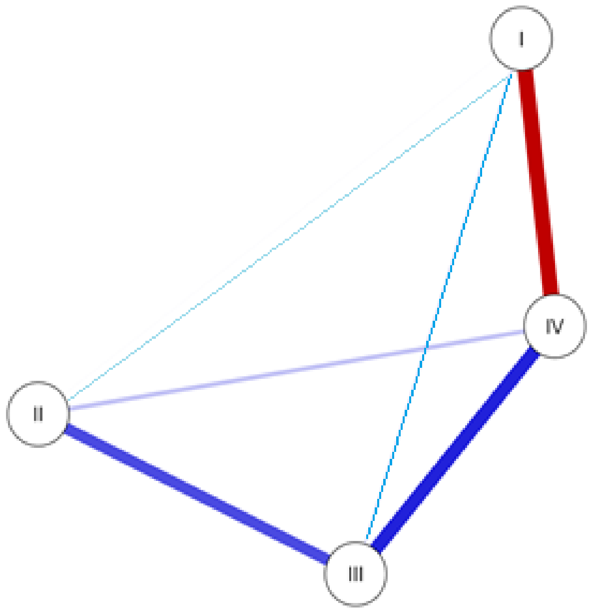

Figure 2 – The similarity of the phytoplankton species composition in the model sections of the Irtysh River according to the analysis of the JASP program

The thickness of the line shows the strength and direction of the correlation. Dark blue is a positive correlation, light blue is a weak positive correlation, and red is a negative correlation. The first and fourth sections of the study have a negative correlation. The species richness of phytoplankton varies significantly in these areas. The Black Irtysh has its unique species composition of phytoplankton.

The general trend shows that the species diversity of phytoplankton communities decreases from the upper part of the river to the lower. The change in the species diversity of river phytoplankton depends on the flow velocity, the time of material collection, and the anthropogenic impact. The phytoplankton sampling area was in the zone of influence of industrial cities. By government study and statistics the quality of the waters of the Irtysh River is assessed as class 1 – the best quality [34]. However, in the impact zone of the cities of Pavlodar, Aksu, rural districts of Zhanabet and Priirtyshskoye, exceedances of MPC values for copper in the waters of the Irtysh River were recorded [35]. There are several industrial sources of chemical pollution in the Pavlodar region: the hydroelectric power plants, coal pits, and a ferroalloy plant. The upper reaches of the Irtysh River are subject to organic pollution due to the insufficient purification of industrial and household wastewater [36].

Conclusion

One hundred fifty-three species and subspecies of algae were found in the summer phytoplankton of the Irtysh River. Most species richness was characteristic of diatoms and green algae. The species richness of planktonic algae decreased from the upper to the lower reaches. However, in the area below the city of Pavlodar, the species richness of phytoplankton increased again. The difference in the number of species at the four sites was slight, which indicates that species may have adapted to the physical and chemical factors of the river environment. However, the species composition of planktonic communities was unique in each site. The JASP program indicates the similarity of the species richness of phytoplankton between the sites of the Black Irtysh and the zones of influence of the cities of Pavlodar and Aksu. The negative trend indicates a discrepancy in species richness between the first three and the fourth sites.

Compared with previous studies, the number of phytoplankton species in the Irtysh River remains almost unchanged. However, it is worth noting that the research covered areas of the middle Irtysh, its tributaries, ponds, and lakes near Omsk [3,5]. Our research covers only the bed of the Kazakhstan part of the Irtysh River, which may affect differences in the number of species.

This study was conducted in one season. Differences in the number of species can be explained by the territorial vastness and temporal coverage, as well as the characteristics of the selected sites for collecting material. Considering these factors is important when comparing the results of different studies.

Further study of phytoplankton in the Irtysh River is essential for a deeper understanding of changes in its species composition, distribution and dynamics. This requires systematic data collection in different seasons and studies on different river sections to study phytoplankton dynamics.

Acknowledgements, conflict of interest

We express our deep gratitude to the project manager, Head of the Laboratory of Hydrobiology and Ecotoxicology “Institute of Zoology” of the National Academy of Sciences of the Republic of Kazakhstan, Doctor of Biological Sciences Elena G. Krupa, for constructive criticism and scientific advice.

There is no conflict of interest among the authors of the article.

Funding

This research was funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan, the Scientific Program "Assessment of biological resources of the Kazakh part of the transboundary Irtysh basin in the context of climate change (BR18574062)."

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Received February 6, 2024
Accepted May 20, 2024