The composition and seasonal dynamics of planktonic green algae in the mouth of the Kazanka River (Republic of Tatarstan).

Khaliullina Liliya Yunusovna, Fazlieva Alina Ravilievna
Kazan Federal University
Liliya-kh@yandex.ru

Abstract:

The article presents the results of studies of the species composition and seasonal dynamics of planktonic green algae in the mouth of the Kazanka River in the city of Kazan in 2018. During the observation period, 51 taxa of green planktonic algae of *Chlorophyceae* and *Trebouxiophyceae* classes were found in the algoflora of the studied area, of which 53% of the species belong to the order *Sphaeropleales spheroplei*. The largest numbers of taxa belong to the families *Hydrodictyaceae* (13%), *Scenedesmaceae* (23%), *Selenastraceae* (10%), *Chlorellaceae* (14%), *Oocystaceae* (10%), *Chlamydomonadaceae* (8%). The total number and biomass range from 1.6-18.8 million cells/liter and 1.2-9.9 mg/liter. Flagellate monadic algae dominate in phytoplankton, belonging to the order *Chlamydomonadales Phacotus lenticularis, Pandorina morum, Chlamydomonas* sp. sp., *Carteria* sp. sp. The species of the spheroplei genera *Scenedesmus, Pediastrum, Coelastrum, Crucigenia, Actinastrum, Dictyosphaerium, Oocystis*. Mass reproduction of these algae throughout the summer and autumn indicates the extreme pollution of the waters in this part of the Kazanka River. Based on the data obtained, an assessment was made of the ecological state of water in the considered section of the river. Water quality is assessed as β-mesosaprobic (1.6-2.5) and moderately polluted; quality class III. According to trophic indices, the water in the considered area for the observation period is mostly consistent with the hypereutrophic type.

Ключевые слова: альгоценоз, водоросли, фитопланктон, река Казанка
Keywords: algocenosis, phytoplankton, algae, the river Kazanka

INTRODUCTION.

Today, the problem of monitoring of the status of water bodies located within the city boundaries is of great relevance. Urban bodies of water, to which the lower part of the Kazanka River belongs, traditionally used as sources of fresh water, as well as for technical, recreational, and other purposes. The functioning of settlements, the gradual expansion of their borders leads to pollution of water bodies by urban, mainly domestic wastewater, in aerotechnogenic way and, as a result, disrupts the natural functioning of water ecosystems and turns them into anthropogenic ones [3].

For the purpose of ecological monitoring of aquatic ecosystems, the study of phytoplankton is actively used, which, due to the structure and functional features, determines the state of aquatic ecosystems in general. The objective of this work is to assess the environmental status of the estuarine area of the Kazanka River by indicators of the structure of communities of planktonic green algae.

MATERIALS AND METHODS.

The Kazanka River is a typical lowland river with mixed food that originates on the western slopes of the Vyatka Slopes and, flowing in a southwestern direction, flows into the Volga River in the city of Kazan. The length of the river, according to various sources, ranges from 140 km to 172 km [7]. The lower course of the Kazanka River, being in a backwater zone by the waters of the Kuibyshev reservoir, has turned into a wide bay. Water masses in the upper and middle currents belong to the hydrocarbonate - calcium class, in the lower reaches downstream the Derbyshki settlement - to the sulfate class and calcium group. The river is characterized by high salinity of water, which increases markedly from the upper reaches to the lower reaches of the river. The upper and middle sections of the river are mainly affected by agricultural runoff, due to which nutrients enter the river. In the lower reaches, man-made impact comes to the fore: sewage from industrial and municipal enterprises and storm sewage enrich the river with toxic compounds of organic and inorganic nature such as oil products, surfactants, phenols, heavy metals with multiple excesses of permissible concentrations. Mineral forms of phosphorus are constantly present in excess concentrations, which contribute to the processes of eutrophication of the river. The river water is highly polluted and is rated as “dirty” (quality grade 4). Decisions of the Council of Ministers of the TASSR No. 25 (dated 10.01.1978) and the Cabinet of Ministers No. 644 (dated 29.12.2005) assigned the Kazanka River the status of a nature monument of regional significance [4], [5]. As a measure of river protection, it is recommended to comply with the regime of protection of the territory of the natural monument, as well as the regime of use of water protection zones. The river has economic and educational significance. The Kazan – Arsk section is recommended for tourism [3].

In 2018, during the growing season, studies were made of planktonic green algae in the mouth of the Kazanka River in the city of Kazan. Permanent observation stations were located in the riverbed of the Kazanka River (near the Kremlin transport dam). The layout of the sampling station is shown in Fig. 1.

Samples were taken once every week. In total, between June and October 2018, 34 qualitative and quantitative samples of algae were collected. Selection and office processing of phytoplankton samples were carried out according to standard methods [6], [2].

Phytoplankton samples were collected from a depth of 0.5 - 2.5 m. All quantitative samples of 0.5L were fixed with 40% formalin solution. The fixed samples were concentrated by sedimentary method to 7-10 ml for qualitative and quantitative measurement of phytoplankton. Also, to thicken phytoplankton, a vacuum filter was used for hydrobiological studies in water PVF-35/NB. For concentration of phytoplankton, Vladipor membrane filters of the MFAS – OS – 2 and MFAS – OS – 3 type with pore sizes of 0.45 and 0.8 μm were used. The counting of organisms was carried out according to the generally accepted technique in the counting chamber. To determine the biomass, the counting-volumetric method was used. For each sample, the trophic index (ITS) was calculated by the Milius block according to the formula $Ib=44.87+23.22*\log B$ [1]. To determine the degree of saprobity of the reservoirs, the Sladechek-modified Pantle-Buck saprobity index (S) was calculated [8].

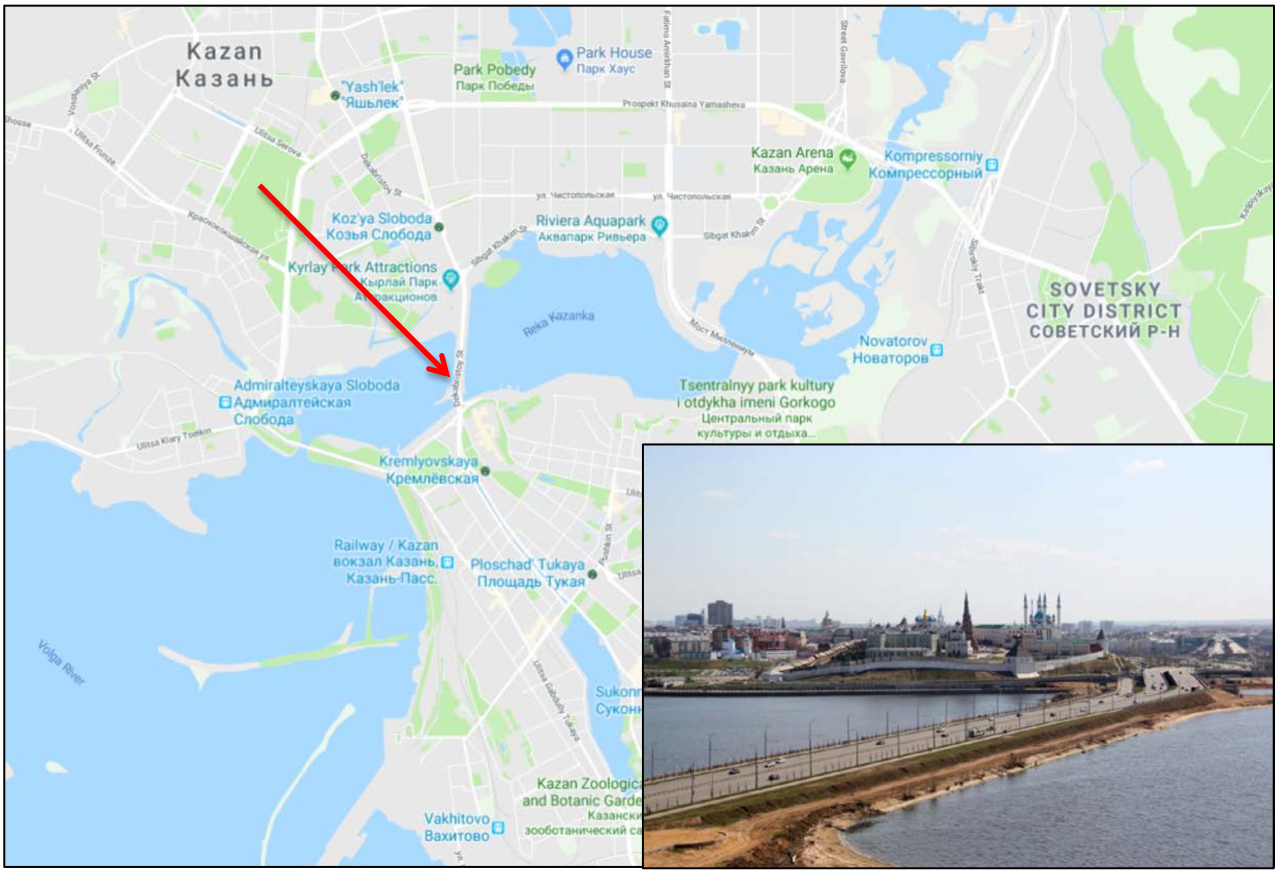

Fig. 1. The location map of the research area of phytoplankton in the Kazanka River (2018).

Over the entire period of research, weather conditions and hydrological characteristics of the river (water level, transparency, weather conditions, etc.) were recorded. The Kazanka River as a river ends at the railway bridge near the village of Derbyshki. Further, within the city limits, the Kazanka River takes the form of the Kazan Bay of the Kuibyshev Reservoir and is a natural and technogenic object. The water level in the Kuibyshev reservoir is regulated by the dam of the hydroelectric power station, which has annual, seasonal and daily regulation, which is observed in this section of the Kazanka River.

RESULTS AND DISCUSSIONS

For the observation period in the algoflora of the investigated area of the Kazanka River we found 51 taxa of green planktonic algae from 2 classes, 3 orders, and 15 families (Table 1).

Table 1. The main systematic groups of planktonic green algae in the estuarine area of the Kazanka River (2018)

Class	Order	Family	Total
Chlorophyceae	*Chlamydomonadales*	*Phacotaceae*	2
		Chlamydomonadaceae	4
		Volvocaceae	2
		Goniaceae	1
		Carteriaceae	1
		Chlorococcaceae	1
		Sphaerocystidaceae	1
	Sphaeropleales	*Hydrodictyaceae*	7
		Scenedesmaceae	12
		Selenastraceae	5
		Treubariaceae	1
		Neochloridaceae	1
		Radiococcaceae	1
Trebouxiophyceae	*Chlorellales*	*Chlorellaceae*	7
		Oocystaceae	5

Species diversity of green algae ranges throughout the study period from 13 to 4 species per sample (Fig. 2-3). The highest occurrence rate is typical of species *Phacotus lenticularis* (Ehr.) Stein., *Chlamydomonas sp*., *Carteria globosa* Korschik., *Scenedesmus quadricauda* (Turp.) Breb., *Scenedesmus acuminatus* (Lagerh.) Chod., *Actinastrum hantzschii* Lagerh., *Crucigenia tetrapedia* (Kirchn.) W.et.W., *Crucigenia rectangularis* (A.Br.) Gay., *Pediastrum duplex* Meyen., *Pediastrum* *boryanum* (Turp.) Menegh., *Dictyosphaerium pulchellum* Wood., *Oocystis natans* Wille., and *Coelastrum proboscideum* Bohl.

Cosmopolitan and planktonic species of algae prevail in terms of environmentally-geographical characteristics. In relation to halobility, most species are indifferent, and in terms of pH the most common are the indifferent and alkaliphile + alkalibiontic algae.

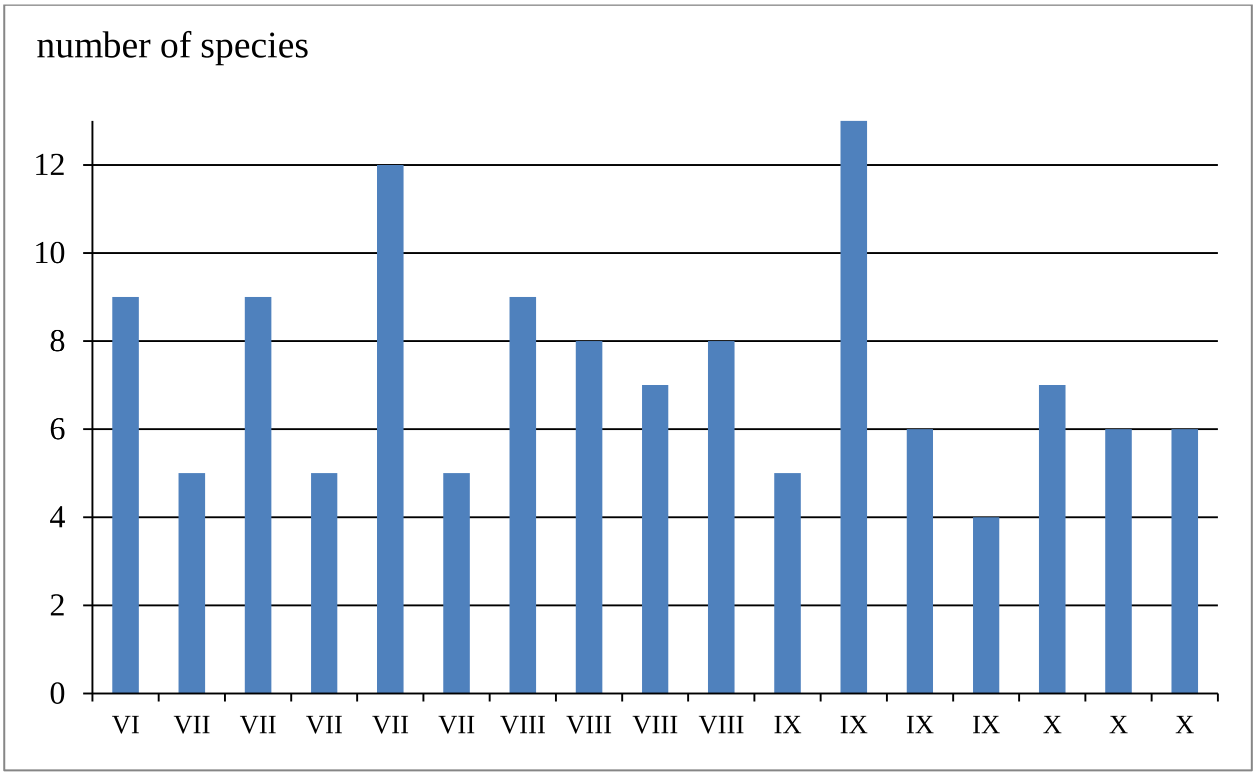

Fig. 2. Seasonal dynamics of the distribution of taxa of planktonic green algae in the mouth of the Kazanka River (2018).

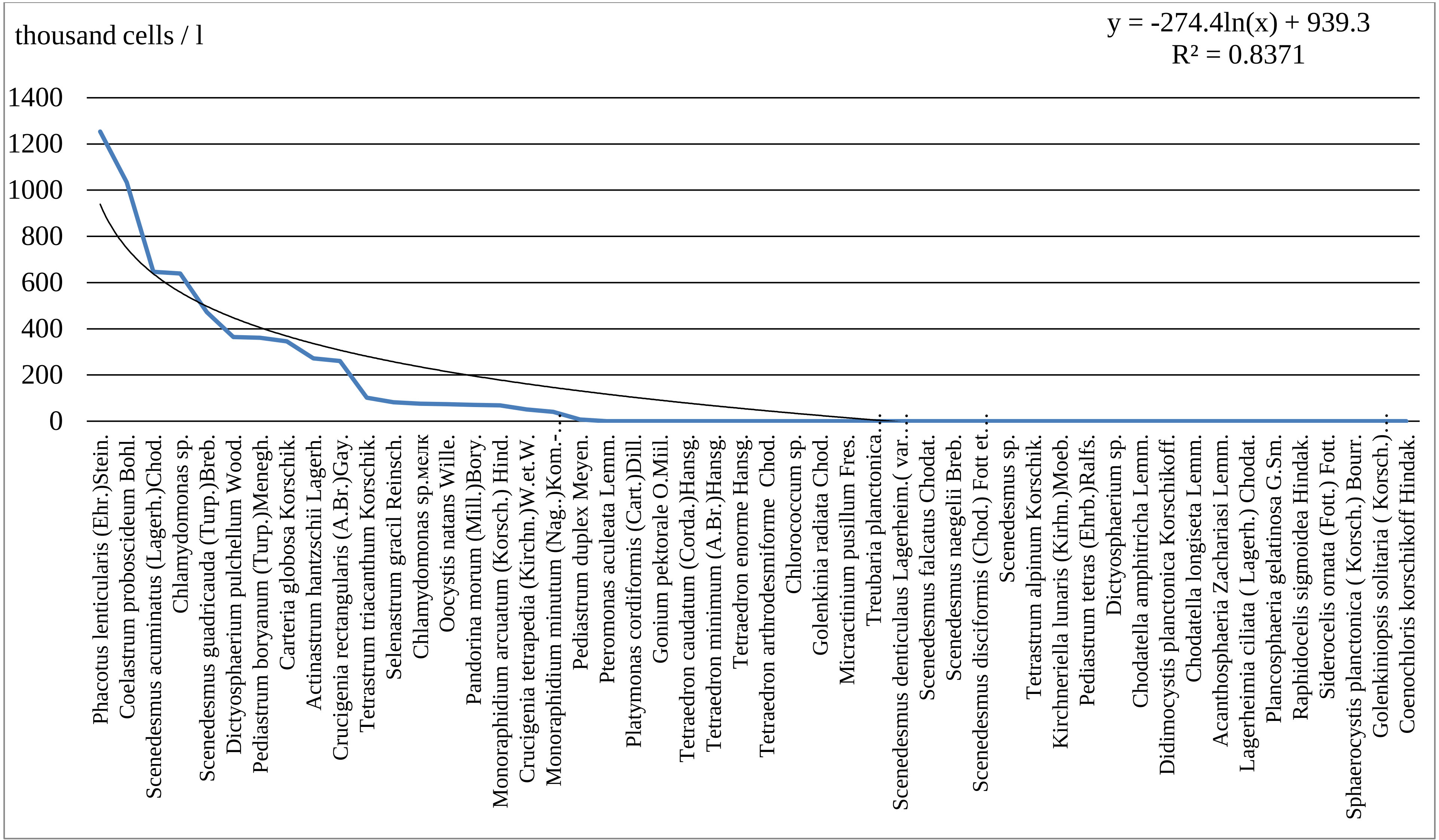

Fig. 3. Distribution of the average abundance (thousand cells/l) of planktonic green algae in the mouth of the Kazanka River (2018).

The quantitative indicators of planktonic green algae during the entire observation period were rather high; the total abundance and biomass varied between 1.64–18.76 million cells/L and 1.22–9.94 mg/L (Fig. 4).

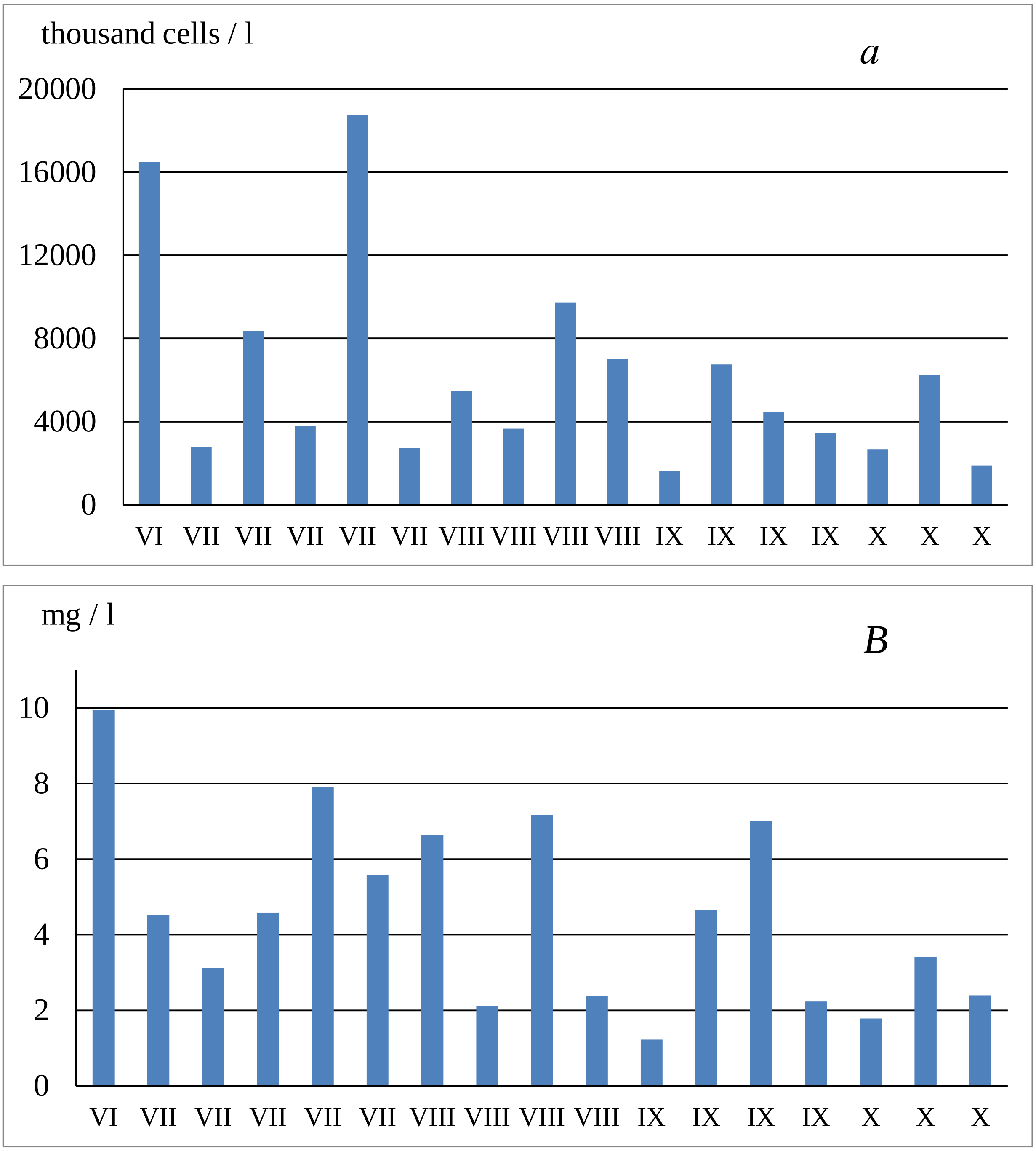

Fig. 4. Seasonal dynamics of abundance (a) and biomass (b) of planktonic green algae in the mouth of the Kazanka River (2018).

The dominant algae in quantitative terms are *Phacotus lenticularis* (Ehr.) Stein., species of the genus *Chlamydomonas*, *Carteria globosa* Korschik., *Scenedesmus quadricauda* (Turp.) Breb., *Scenedesmus acuminatus* (Lagerh.) Chod., *Pediastrum duplex* Meyen., *Pediastrum boryanum* (Turp.) Menegh., *Coelastrum proboscideum* Bohl., *Pandorina morum* (Mill.) Bory., *Actinastrum hantzschii* Lagerh., *Crucigenia tetrapedia* (Kirchn.) W.et.W., *Crucigenia rectangularis* (A.Br.) Gay., *Dictyosphaerium pulchellum* Wood., *Oocystis natans* Wille., *Tetrastrum triacanthum* Korschik.

In the seasonal dynamics of planktonic green algae, the maximum abundance and biomass were observed at the very beginning of summer, then from the second decade of July to mid-August. If the first maximum of phytoplankton development was due to the multiplication of flagellar algae *Phacotus lenticularis*, then the second half of summer is characterized by a set of phytoplankton consisting of algae of the genera *Chlamydomonas*, *Carteria* and spheroplei (Fig. 5-6). *Phacotus lenticularis* - a mass species of summer phytoplankton of many relatively deep, stratified lakes and is a calcephilus. In this species, the cell membrane is impregnated with iron salts and the shells are thick and calcined. The massive development of this organism is characteristic of mineralized waters with a high content of calcium. This is a widespread species, especially in eutrophic lakes and ponds, often causing the "bloom" of water, α-β - mesosaprob.

In general, the dominance of flagellate monadic algae in the water belonging to the order *Chlamydomonadales* indicates a strong pollution of the reservoir. These are typical inhabitants of shallow eutrophic and hypertrophic pond-type lakes and for the most part are α-β-mesosaprobes.

An important role in biomass and abundance in this section of the river is also played by the spheropley algae of the genera *Scenedesmus, Pediastrum, Coelastrum, Actinastrum, Crucigenia, Dictyosphaerium*. Many spheric algae can have both planktonic and benthic lifestyles and assimilate biogenes from various sources, including bottom sediments, both in mineral and organic forms. It is known that green algae are characterized by a high demand for nitrogen. Many of them prefer a medium rich in amino acids than a mineral medium and are optional heterotrophs. Thanks to this “opportunistic” way of life and the ability to use random sources of nutrition, they are relatively easy to adapt to environmental changes and, along with blue-green algae, can tolerate severe pollution, including oil pollution. Elevated concentrations of biogens and petroleum products only stimulate the growth of many representatives from this group.

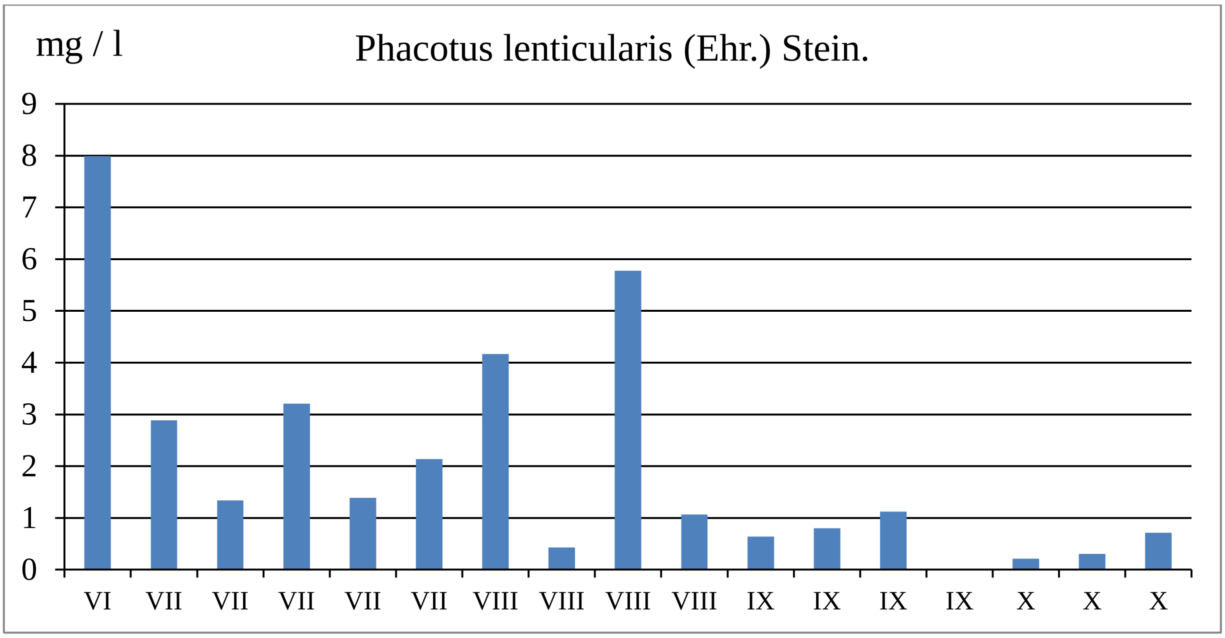

Fig. 5. Seasonal biomass dynamics (mg/l) of the dominant species *Phacotus lenticularis* in the mouth of the Kazanka River (2018).

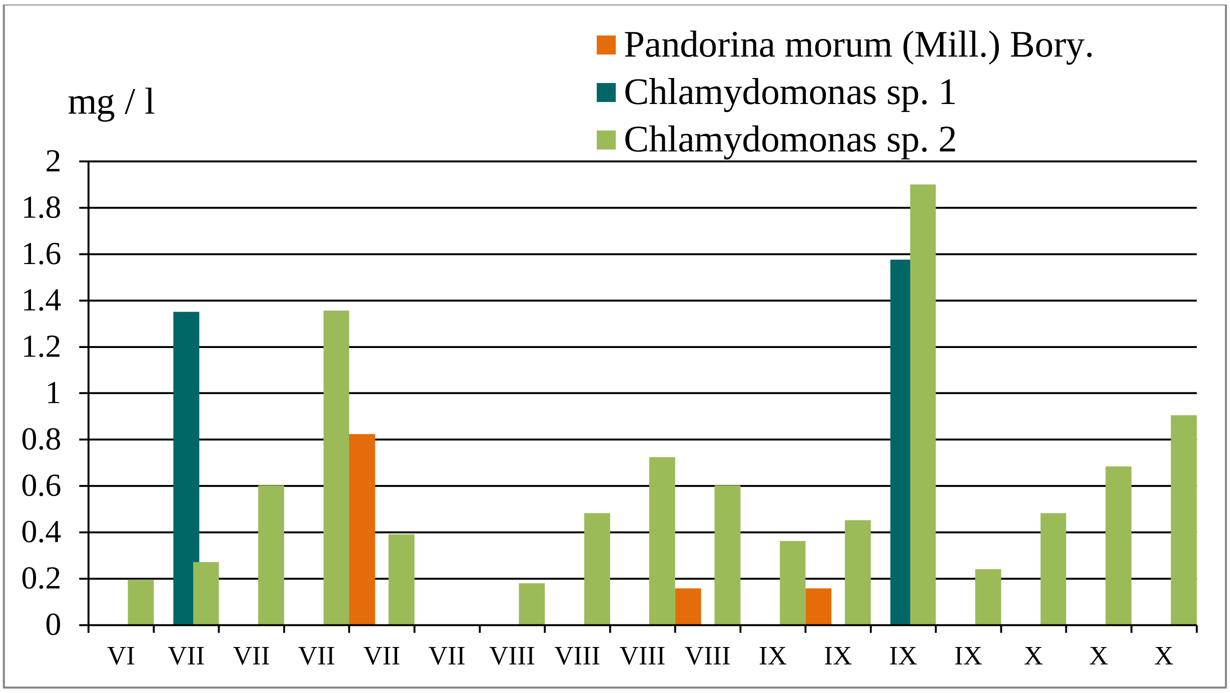

Fig. 6. Seasonal biomass dynamics (mg/l) of the dominant species of planktonic green algae in the mouth of the Kazanka River (2018).

To determine the degree of saprobity of this section of the river, the Sladechek-modified Pantle-Buck saprobity index (S, P/A) was calculated from the phytoplankton biomass. As calculations showed, water quality is estimated as β-mesosaprobic (1.6-2.5) and moderately polluted; quality class III (Fig. 7). Also, indicators of the quantitative development of phytoplankton are widely used to characterize the status and trophic status of water bodies. According to the results obtained, the water in the area under consideration during the observation period mostly corresponded to the hypereutrophic type.

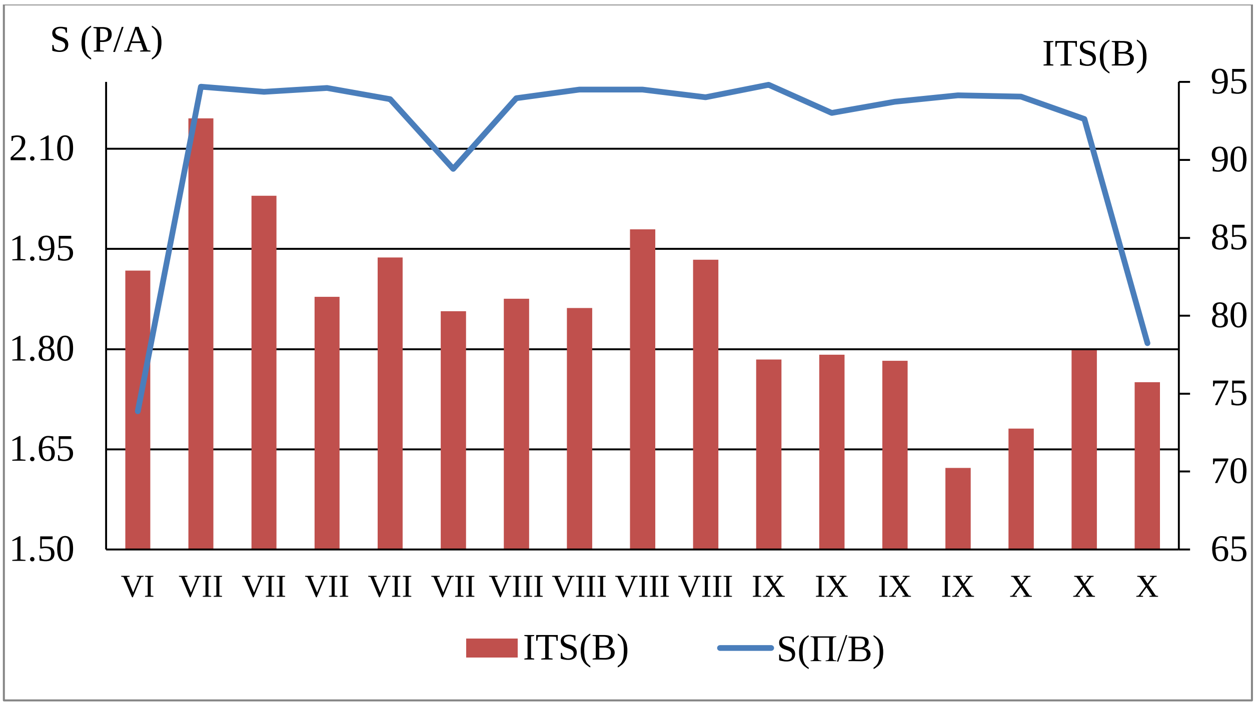

Fig. 7. Dynamics of trophic (ITS) and saprobity indices by biomass (S) of planktonic green algae species in the estuarine part of the Kazanka River (2018).

During the study, the coefficients of Spierman correlation between the indices of phytoplankton, water temperature and clarity, pH, and water level fluctuation were calculated, and some relations were found. A negative correlation (r = -0.6 - -0.7) is observed between the quantitative indicators of *Carteria globosa* and the transparency of water, as well as pH. An increase in the *Phacotus lenticularis* content in water was noted at higher values of water temperature (r =

0.7), pH (r = 0.6) and water level (r = 0.8). An increase in trophicity of water also correlates with an increase in the abundance and biomass (r = 0.7) of this dominant. The trophicity of water increases with increasing water temperature (r = 0.7), which leads to an increase in pH (r = 0.8). Such kind of dependencies in nature usually have a causal and hereditary indirect character.

SUMMARY

The dominant algae in phytoplankton of the Kazanka River are by flagellar monad algae from the order *Chlamydomonadales*, as well as numerous species of the order *Sphaeropleales*. All these are algae species that prefer a high content of organic substances in water. For the most part, these are cosmopolitan, typically planktonic species of algae, the mass reproduction of which throughout the summer and autumn indicates the extreme pollution of the waters in this part of the Kazanka River. These are typical inhabitants of shallow eutrophic and hypertrophic pond-type lakes and for the most part are α-β-mesosaprobes.

Based on the data obtained, an assessment of the current ecological state of the water of the considered section of the river is carried out. Water of the Kazanka River in 2018 for most of the growing season was β-mesosaprobic and corresponded to a moderately contaminated zone. Trophic status of the Kazanka River in the study area corresponded in most of the time to the hypereutrophic type.

CONCLUSION

The mouth of the Kazanka River today is a highly polluted low-flowing shallow water body, with a strong siltation and accumulation of suspended solids and oil products from surface wastewater. Currently, one of the main environmental problems of large cities is the pollution of urban water bodies with surface wastewater. Surface runoff from the city is one of the strongest sources of water pollution by various impurities of natural and technogenic origin. Surface runoff is formed from rain, melt and irrigation water in the built-up areas of the city and in the territories of industrial enterprises and should be organized in an organized way through a storm or general alloy sewer network to sewage treatment plants. However, today in Kazan, all these activities are insufficiently implemented.

The results of these studies are of considerable theoretical and practical value. The results obtained in 2018 were applied in monitoring and forecasting studies of the rivers of the Republic of Tatarstan.

This study was performed in accordance with the State Program of Competitive Growth of the Russian Federation at Kazan Federal University.

ACKNOWLEDGMENTS:

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

REFERENCES

[1] Andronikova I.N. Classification of lakes by the level of biological productivity // Theoretical problems of lake classification. - St.P.: “Nauka”, 1993. - p. 51-72.

[2] Algae. Reference book. - Kiev: Nauk. Dumka, 1989. - p. 608

[3] Water bodies of the Republic of Tatarstan / Hydrographic directory. - Kazan: "Idel-press” Publishing house, 2006. - p. 504

[4] The state register of specially protected natural territories in the Republic of Tatarstan / Kazan: Idel-press, 2007. - 2nd ed. - p. 408

[5] The state register of specially protected natural territories in the Republic of Tatarstan / Kazan: Magarif, 1998. - p. 315

[6] The methodology of studying biogeocoenosis of inland waters. - M.: “Nauka”, 1975 - p. 240

[7] Nikanorov A.A., Zakharov S.D., Bryzgalo V.A., Zhdanova G.N. The rivers of Russia. Part III: Rivers of the Republic of Tatarstan (hydrochemistry and hydroecology). - Kazan: Publishing house of IPK "Brig", 2010. - p. 224

[8] Sadchikov A.P. Methods of studying freshwater phytoplankton. - M.: “Universitet i Shkola”, 2003. - p. 200