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**Research Article**

# Seasonal Dynamics of Phytoplankton of the Sviyaga River (Right Tributary of The Volga River, The Republic Of Tatarstan)

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**ABSTRACT:**
The report presents the results of studies of seasonal dynamics of planktonic algae of the Sviyaga River (the right tributary of the Volga River), which is a monument of nature of regional importance. Studies were carried out at two permanent stations in the open water zone, and inthe thickets of macrophytes*Typhaangustifolia* L.
Seasonal dynamics of phytoplankton of the Sviyaga River is characterized by two peaks of abundance and biomass - summer and summer-autumn. During these periods the maximum values of quantitative indicators are observed. In the summer-autumn period, the "blooming" of water is associated with the massive development of Cyanophyta*Aphanizomenonflos-aquae*. The dynamics of phytoplankton communities is determined mainly by seasonal changes in hydrometeorological conditions.
Based on the data obtained, the assessment of current ecological state of water in the studied area of river was carried out. During the major part of the growing season, the water of the Sviyaga River in 2014 referred to the β-mesosaprobic type, and corresponded to the moderately polluted zone. The trophic status corresponded to the mesotrophic type, and during the periods of maximum development of planktonic algae - to the eutrophic type.

**KEYWORDS**: algocenosis, phytoplankton, algae, the Sviyaga River.

## INTRODUCTION.

Small rivers in the Republic of Tatarstan, for the most part, are subjectedto intense anthropogenic impact on the watercourses,due to the economic and other human activities. For today, the ecology of small riversin Russia, as well as the peculiarities of structural organization of biological communities in them are understudied, in comparison with large rivers and reservoirs [Information bulletin on the state of surface water bodies, 2007]. Also, theshortcoming of monitoring system, used for small rivers, as well as for most other water bodies, is an inadequate study of the seasonal dynamics of hydrobionts.

Plankton algae (phytoplankton) play a decisive role in the formation of water quality, and the assessment of the state of water bodies. Its taxonomic composition, structure and level of quantitative development are the integral indicators of the features of river ecosystems. They allow to determine the specificity of influence of the main natural and abiotic factors on them. At present, there is very little published information on the phytoplankton of small rivers of the Republic of Tatarstan. There are only episodic and non-systematic data [Nikanorov A.A., Zakharov S.D., Bryzgalo V.A., Zhdanova G.N. 2010; Ecological problems of small rivers of the Republic of Tatarstan ,2003].

This report presents the results of studies of seasonal dynamics of plankton algae in theSviyaga River.On the basis of data obtained, the assessment of current ecological state of

water in the studied section of river was carried out.

The SviyagaRiver – is the right tributary of the Volga River. It joins the Volga on the territory of the Republic of Tatarstan, in the Sviyazhsky Bay of the Kuibyshev Reservoir. The Sviyaga and all its sources are the monument of nature of regional importance. Despite the fact, that the status of the river presupposes compliance with the protection of territory of the nature monument, as well as the regime of use of water protection zones, in the order established by law, the SviyagaRiver and most of its tributaries experience significant anthropogenic load throughout its entire length. The main polluters are agricultural and production objects, which are not equipped with localpurification and treatment facilities. The pollution of the river is also a result of non-compliance of agricultural enterprises with anti-erosion agrotechnical measures for soil cultivation, ploughing of lands, adjacent to water bodies, application of mineral fertilizers and pesticides. The soil, manure, fuel and lubricants, oil products are washed awaywith rain floods and spring high water. This situation worsens the sanitary state of the river, flowing through the territories of settlements [Water resources and drinking water of Tatarstan / 1997]. For example, currently, in the city of Ulyanovsk, the water of the Sviyaga River is so polluted that bathing in the river is prohibited.

**MATERIALS AND METHODS.**

Catchment area of the SviyagaRiver is located on the high right bank of the middle reach of the Volga River, in the northeast of the Volga Upland, and flows from the south to the north, parallel to the Volga, along the asymmetric high undulating plain, strongly intersected by numerous deep (sometimes up to tens of meters) ravines and gullies. The total area of the river basin is 16,700 $km^2$. The greatest length from the south to the north is about 260 km, from the west to the east - 120 km. The river bed is meandering; the width of the river is 20-30 m. The average depth at the ripples is 0.6 m, at the reaches - 1.3 m. The length of the river is 375 km, of which 205 km are within the boundaries of the Republic of Tatarstan. The width of the river varies from 5 to 40 m;the depthin the dry-weather periodis 0.3-4.0 m;the current speed varies from 0.1 to 1 m/s. The river has 79 tributaries, many of which are regulated [Ecological problems of small rivers of the Republic of Tatarstan,2003].

The river is abundant. The nourishment of river is mixed, mostly snow (up to 52%). The average annual water consumption is 34 $m^3$/s. It freezes in November-early December, and breaks up in April. The hydrological regime is characterized by high flood and low long dry-weather period.

The water in the river varies in qualitative composition from hydrocarbonate-sulphate-calcium (up to the Birlya River) to sulfate-hydrocarbonate-sodium to the mouth. The hardness of water ranges from 1.5-3.0 meq/l in spring, to 3.0-6.0 meq/l in thedry-weather period.

The water has low hardness in spring (1.5-3.0 meq/l), and moderate hardnessin the dry-weather period (3.0-6.0 meq/l). It has high salinity (400-1100 mg/l) during the year. In the period of spring high water the total content of ions decreases to 150-200 mg/l. The longitudinal heterogeneity of chemical composition of water is due to the regular changes from the upper sections to the lower reaches, as well as due to the influence of tributaries [Nikanorov A.A., Zakharov S.D., Bryzgalo V.A., Zhdanova G.N. 2010].

The share of easily oxidized organic matter rarely is above 50% of the COD value and varies from 30 to 40%. Concentrations of organic pollutants (petroleum products, phenols, surfactants) are within the normal range during the entire observation period [Water resources and drinking water of Tatarstan / 1997].

Currently, in the catchment area of the river, there are small filtration fields of OAO BuinskySakharnyZavod and city sewage treatment facilities of Buinsk. In addition, the river is located in the sanitary protection zones of biological treatment facilities of OOO BuinskyMashinostroitelnyZavod, a subsidiary of OAO Tatspirtprom and BuinskySpirtzavod, located in the city of Buinsk. These treatment facilities largely prevent the negative impact of

industrial production on surface and groundwater, but it should be noted that emergency situations at these sites sometimes cause significant damage to the water resources of the river [Ivanov D.V., Shagidullin R.R., Ziganshin I.I., Osmelkin E.V. 2011].

The research area is located in a climatic region, characterized by a temperate continental climate, with sufficient moisture, warm summers and moderately cold winters.

The studies of seasonal dynamics of plankton algae were carried out in the period of May-September 2014, near the settlement Cherki-Kildurazy in the Buinsky district of the Republic of Tatarstan (middle-lower course of the Sviyaga River). Weather conditions were monitored in parallel with sampling (Table 1).

**Table 1.** Dates of phytoplankton sampling and meteorological conditions, 2014

| Sample № | Date of sampling | Air temperature ($^0$ C) | Cloud coverage |
|---|---|---|---|
| 1 | 29.05.2014. | +16 | Mostly sunny |
| 2 | 05.06.2014. | +30 | Mostly sunny |
| 3 | 12.06.2014. | +14 | Mainly cloudy, little rain |
| 4 | 19.06.2014. | +16 | Mainly cloudy |
| 5 | 26.06.2014. | +20 | Mainly cloudy |
| 6 | 03.07.2014. | +28 | Cloudy, rain |
| 7 | 10.07.2014. | +22 | Mainly cloudy, little rain |
| 8 | 17.07.2014. | +29 | Sunny |
| 9 | 24.07.2014. | +30 | Sunny |
| 10 | 31.07.2014. | +21 | Mainly cloudy, thunder |
| 11 | 07.08.2014. | +28 | Mostly sunny |
| 12 | 14.08.2014. | +25 | Mainly cloudy, little rain |
| 13 | 21.08.2014. | +24 | Mostly sunny |
| 14 | 28.08.2014. | +15 | Cloudy, rain |
| 15 | 04.09.2014. | +24 | Mainly cloudy |
| 16 | 11.09.2014. | +23 | Mainly cloudy |
| 17 | 18.09.2014. | +23 | Mainly cloudy |

The selection of integrated samples was carried out at two permanent stations,in the open water area without thickets of macrophytes, and in the thickets of macrophytes (narrow-leaved catoptric -

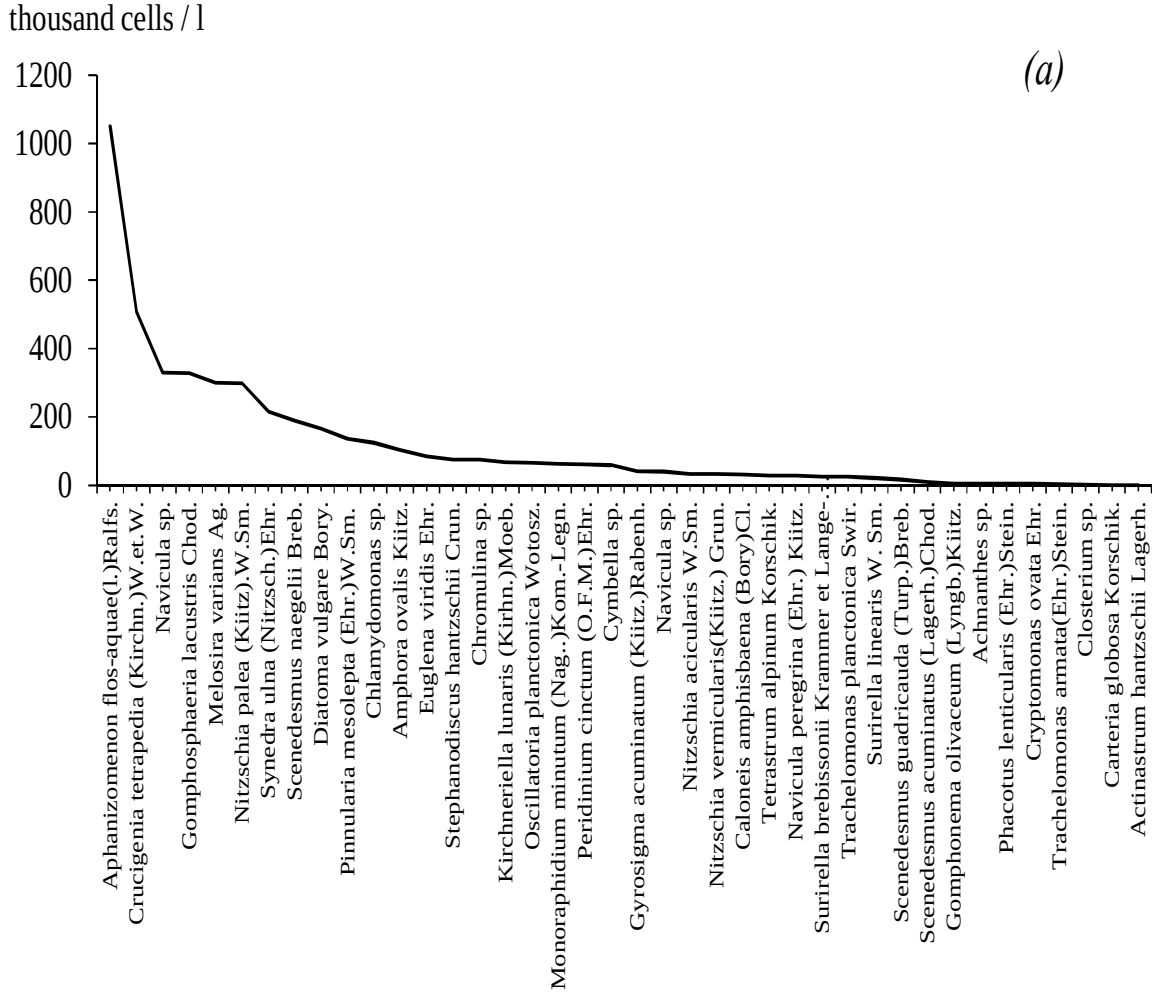
*Typhaangustifolia L.*). Sampling and laboratory investigation of phytoplankton samples were carried out according to the generally accepted methods [The methodology of studying of biogeocenoses of inland water bodies. 1975.;Sadchikov A.P. 2003.]. The samples of phytoplankton were taken using the Molchanov bathometer. 40 quantitative and qualitative samples of plankton algae were collected in total. All quantitative samples, having the volume 0.5 litre, were fixed with 4% formalin solution. Fixed samples were concentrated in 2 stages, using settling method,to 10-20 ml. Qualitative water samples were concentrated by direct filtration through membrane filters in two stages - with a pore diameter of 3-5 μm and 1.2-1.5 μm, and they were studied being alive.

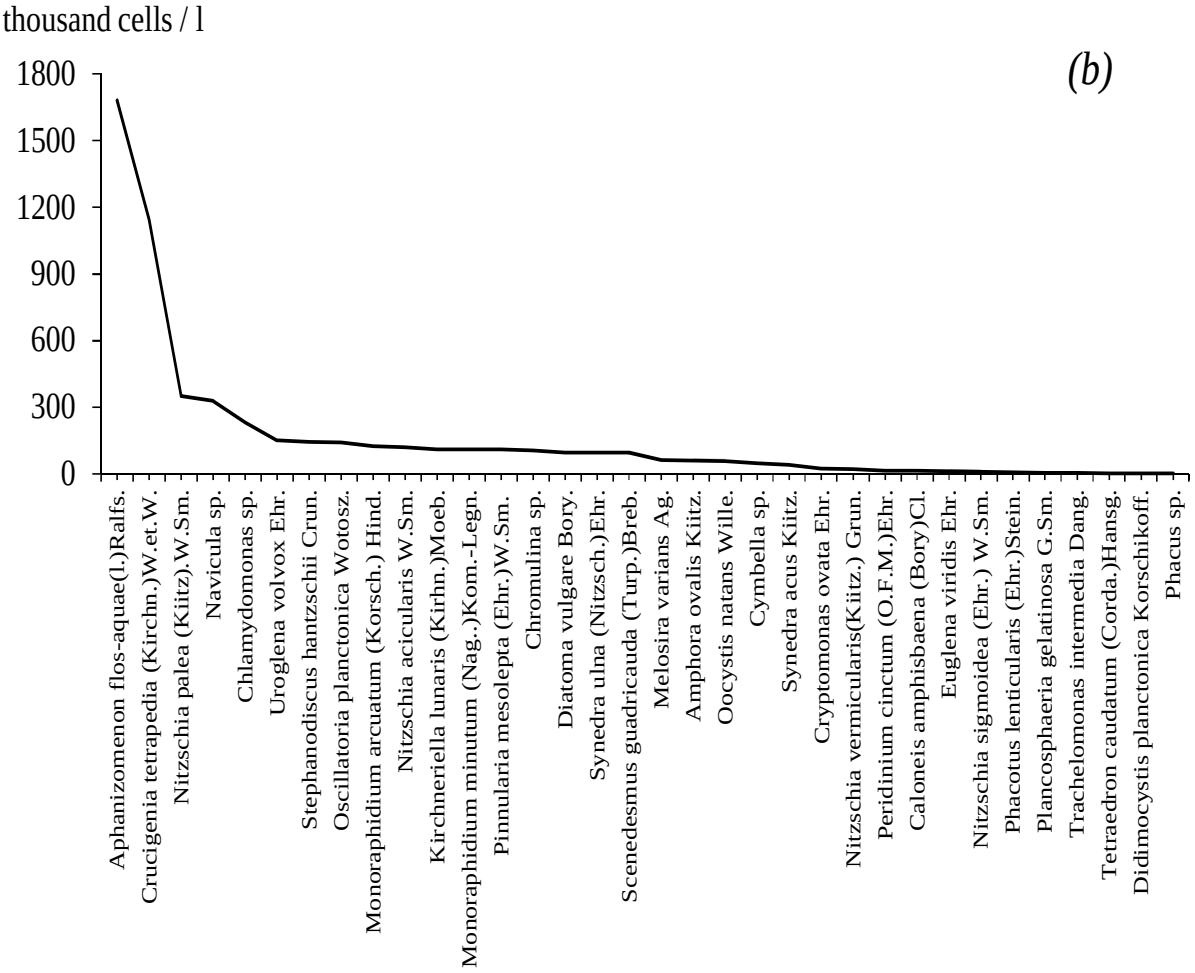
**RESULTS AND DISCUSSIONS.**

In the course of the present work, the analysis of seasonal dynamics of abundance and biomass of plankton algae was carried out. In the composition of dominant species of the studied biotopes, no significant differences were observed. In quantitative terms, both in open water areas and in thickets of macrophytes, the same species of algae prevail, only the ratio between them varies (Figure 1).

The average abundance and biomass of phytoplankton in the open water area were 4.66 ± 1.05 mln.cells/l and 5.56 ± 1.48 mg/l. Bacillariophytapredominate in abundance and biomass. They account for 44.3% of the total abundance and 57.6% of the total biomass. Other groups were less developed: Cyanophytaamounted to 20.6% of the total abundance, and 2.9% of the total biomass, Chlorophyta- 26.8% and 15.8%, respectively. Euglenophyta(2.8% of total abundance and 6.6% of total biomass), Chrysophyta(3.0% of total abundance and 2.6% of total biomass) and Dinophyta(2.2% of total abundance and 13.5% of total biomass) developed less massively.

**Figure 1.** Distribution of the average abundance (thousand cells/litre) of the dominant phytoplankton species of the Sviyaga River in the open water area (a) and in the thickets of macrophytes (b), 2014.






In this area, the following species are predominant in abundance and biomass:Cyanophyta*Aphanizomenonflos-aquae*(l.) Ralfs.,*Oscillatoriaplanctonica*Wotosz., Euglenophyta*Euglena viridis*Ehr., *Trachelomonasplanctonica*Swir., *Tr. armata*(Ehr.) Stein., Dinophyta*Peridiniumcinctum*(O.F.M.) Ehr., Bacillariophyta*Caloneis amphisbaena* (Bory) Cl., *Melosiravarians*Ag., *Synedra ulna* (Nitzsch.) Ehr., *Navicula* sp., *Diatomavulgare*Bory., *Stephanodiscushantzschii*Crun., *Nitzschiapalea*(Kiitz).W.Sm., *Amphora ovalis*Kiitz., *Pinnularia*sp., *Cymbella*sp., Chlorophyta*Chlamydomonas* sp., *Scenedesmusguadricauda*(Turp.) Breb., *Crucigeniatetrapedia*(Kirchn.) W.et.W. and Chrysophyta*Chromulina*sp.

The average abundance and biomass of phytoplankton in the thickets of macrophytes during the study period were 5.55 ± 1.75 mln.cells/l and 3.25 ± 0.77 mg/l. Bacillariophytaalso prevail in abundance and biomass. They account for 30.2% of the total abundance and 59.6% of the total biomass. As for the other groups, it was observed a high quantity of Cyanophyta (31.7% of the total abundance and 9.1% of the total biomass), and Chlorophyta (33.2% and 19.5%, respectively). Euglenophytaaccounted for 0.7% of the total abundance and 2.5% of the total biomass,Chrysophyta- 3.2% and 2.4%, and Dinophyta - 0.6% and 5.3%, respectively.

The complex, consisting of the following algae species, dominates in this area:Cyanophyta*Aph. flos-aquae*, Euglenophyta*E. viridis*, *Trachelomonas intermedia* Dang., *Phacus*sp., Dinophyta*P. cinctum*, Bacillariophyta*C. amphisbaena*, *M. varians*, *S. ulna*, *Synedra*acusKiitz., *Navicula* sp., *D. vulgare*, *St. hantzschii*, *Nitzschiapalea*(Kiitz).W.Sm., *N. acicularis*W.Sm., *N. sigmoidea*(Ehr.) W.Sm., *N. vermicularis*(Kiitz.) Grun., *A. ovalis*, *Pinnularia*sp., *Cymbella*sp., Chlorophyta*Chlamydomonas* sp., *Sc. guadricauda*, *Cr. tetrapedia*, *Kirchneriellalunaris*(Kirhn.) Moeb., *Monoraphidiumarcuatum*(Korsch.) Hind., *M. minutum*(Nag.) Kom.-Legn. W.et.W, Chrysophyta*Chromulina*sp., *Uroglenavolvox*Ehr. иCryptophyta*Cryptomonasovata*Ehr.

As studies show, phytoplankton in the open water area is characterized by higher species diversity and abundance. The increase in the total abundance of phytoplankton in the thickets of macrophytesby the end of summeris due to the massive development of Cyanophyta.They cause the blooming of water during this period, and sometimes stay in the thickets.

Most of the algae, found in the thickets of macrophytes, are diatom pennateperiphyticspecies, such as *Navicula sp., Nitzschiavermicularis, Nitzschiapalea, Synedra ulna, Cocconeisplacentula,* etc., which do not develop massively in areas with open water with rapid currents.Rheophilic centric diatoms,preferring planktonic life, are more common in open water areas. This is facilitated by the hydrological features of the river. There are the following species: *Stephanodiscushantzschii, Melosiravarians, Cyclotellacomta*, and others.

Dynamics of phytoplankton communities during the vegetative period of the Sviyaga River is mainly determined by seasonal changes in hydrometeorological conditions (Figures 2-3). In early summer, the diversity of phytoplankton is poor, and its content in water is not high. Further, with an increase in the temperature of water and air, the abundance ofChlorophyta and Bacillariophytaincreases.

**Figure 2.** Seasonal dynamics of phytoplankton abundance (million cells/litre) in the open water area (a) and in the thickets of macrophytes (b), 2014: 1 - Cyanophyta, 2 - Euglenophyta, 3 - Dinophyta, 4 - Bacillariophyta, 5 - Cryptophyta, 6 - Chrysophyta, 7 - Chlorophyta.

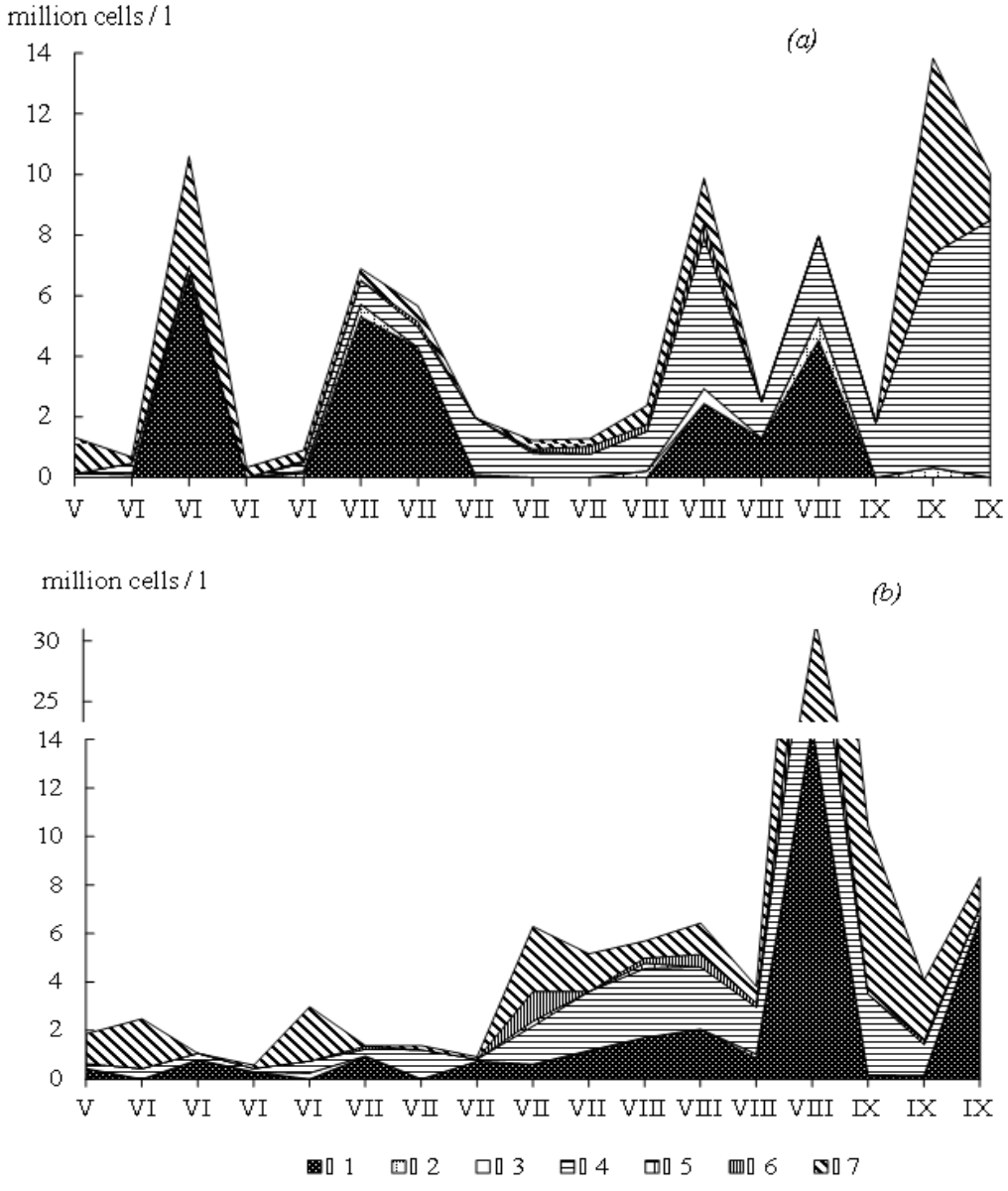
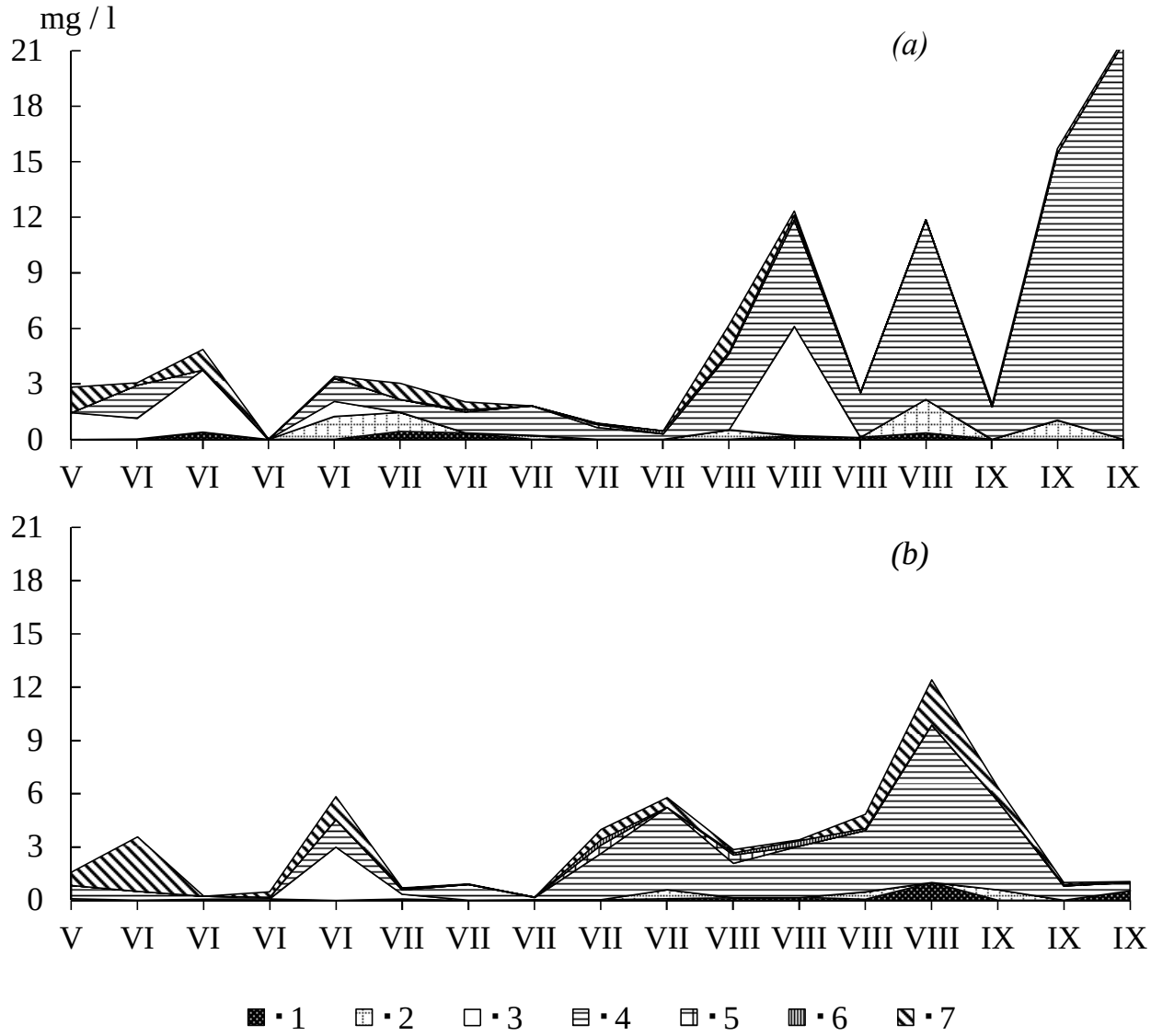


**Figure 3.** Seasonal dynamics of biomass (mg/l) of phytoplankton in the open water area (a) and in the thickets of macrophytes (b), 2014: 1 - Cyanophyta, 2 - Euglenophyta, 3 - Dinophyta, 4 - Bacillariophyta, 5 - Cryptophyta, 6 - Chrysophyta, 7 - Chlorophyta.



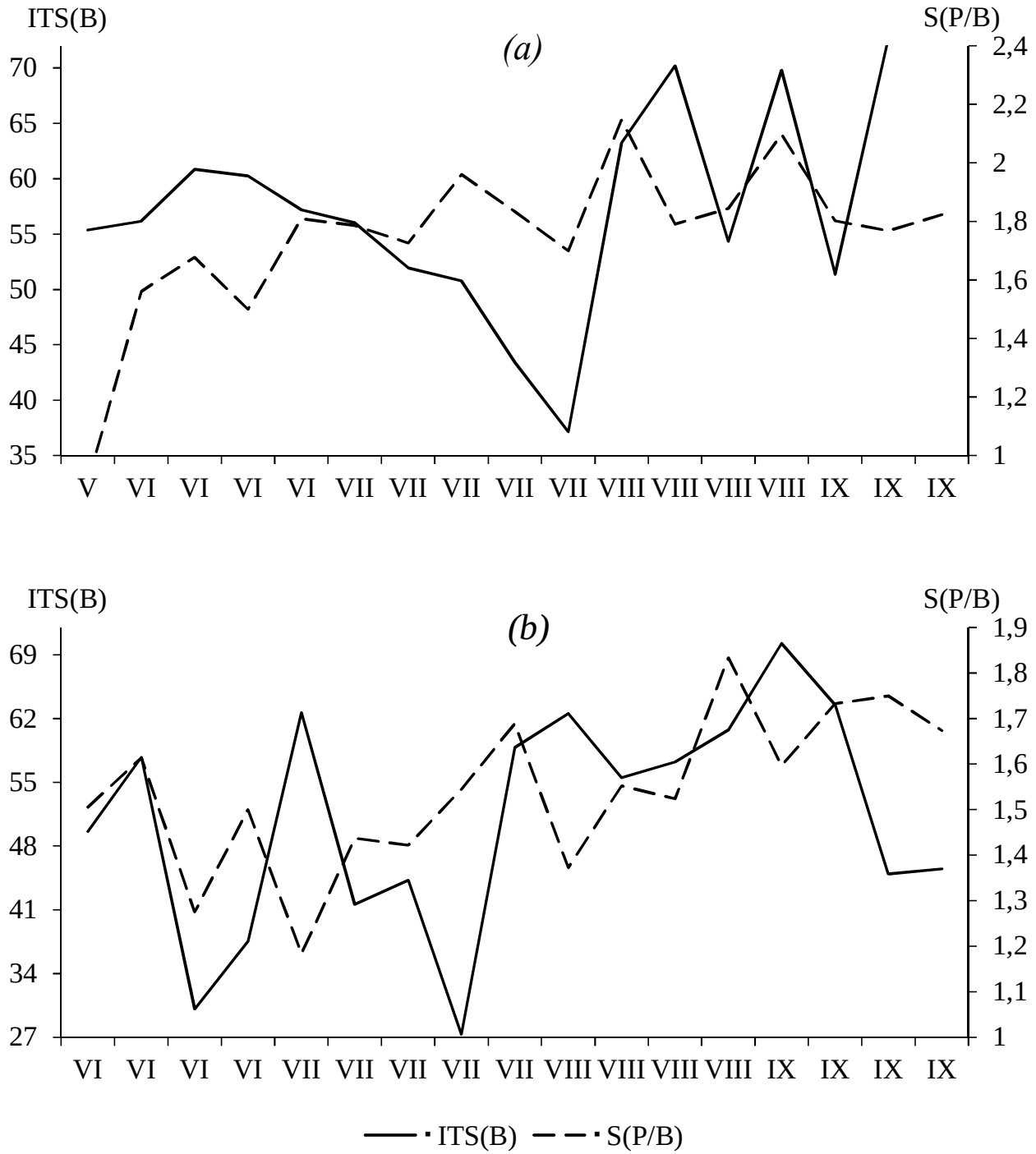

By the end of summer, the content of Chlorophyta Volvocales, Chlorococcales and Cyanophytain water increases and they determine the composition of phytoplankton. Along with them,Euglenophyta,Dinophyta and Bacillariophyta intensively develop during the summer.

Despite the intermittent nature of curves,showing the seasonal dynamics of phytoplankton abundance and biomass, two peaks of abundance and biomass can be distinguished-summer and summer-autumn, when maximum values of quantitative indices are reached. In the summer-autumn period, the "blooming" of water is associated with the massive development of Cyanophyta*Aphanizomenonflos-aquae*, which can be up to 14.57 million cells/litre in the thickets of macrophytes.

In the course of our work, statistical processing of obtained data was also carried out, using the software Microsoft Excel and STATISTICA. Statistical indices of the variables, characterizing the distribution of phytoplankton in the investigated areas, show that the data obtained are highly scattered, and do not correspond to the law of normal distribution of series of variables. More frequent and long-term studies are needed to obtain more representative and reliable data, which would allow to have more detailed and predictive statistical analysis.

The indices of quantitative development of phytoplankton are widely used to characterize the status and trophic status of water bodies. To determine the degree of water saprobity in the investigated areas of the river, the saprobity index of Pantle and Buck in the modification of Sladechek (S, P/B) was calculatedon the basis of phytoplankton biomassin the course of the work. As calculations have shown, water in the Sviyaga River in 2014 could be referred to the mesosaprobic type, and the water quality corresponded to the moderately polluted zone (Figure 4).In addition, water in open areas was characterized by highervalues of saprobity index.

**Figure 4.** The dynamics of trophicity index (ITS) and saprobity index (S (P/B)), calculated on the basis of biomass of the Sviyaga River phytoplankton, in the open water area (a) and in the thickets of macrophytes (b), 2014.




The trophicity indices, calculated using the Milius block for assessment of the trophic status of water bodies [Andronikova I.N. 1993], characterized the biotopes in the studied area as mostly mesotrophic,

and in the periods of maximum development of planktonic algae - mostly eutrophic types (40-60-mesotrophic, 60-80-eutrophic).

**SUMMARY .**

In the seasonal dynamics of phytoplanktonof the Sviyaga River there are two peaks of abundance and biomass - summer and summer-autumn. During these periods, the maximum values of quantitative indicators are observed. In the summer-autumn period, the "blooming" of water is associated with the massive development of Cyanophyta*Aphanizomenonflos-aquae*. The dynamics of phytoplankton communities is determined mainly by seasonal changes in hydrometeorological conditions.

**CONCLUSIONS.**

It should be noted, that during the major part of the growing season, the water of the Sviyaga River in the studied area in 2014 referred to the β-mesosaprobic type, and corresponded to the moderately polluted zone. The trophic status of the Sviyaga River in the researched area corresponded to the mesotrophic type, and during the periods of maximum development of planktonic algae - to the eutrophic type.

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