ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Seasonal Dynamics of Planktonic Algae in The Right Bank of the Volga Reach of the Kuibyshev Reservoir.

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ABSTRACT

The paper deals with the seasonal dynamics and spatial distribution patterns of planktonic algae in the right bank of the Kuibyshev reservoir (the Volga river) during growing season (June-September) of 2015. The Kuibyshev reservoir (Republic of Tatarstan, Russia), formed as a result of the river Volga stanching with a dam of the Volga hydroelectric station, has a pronounced coastal asymmetry. Along the right bank there stretches the Volga Upland and rocky Zhiguli Mountains. The left bank is mostly flat and low-lying. The large difference between the right and left banks causes the differing hydrological conditions along the reservoir, which affect the living conditions of aquatic organisms, and especially planktonic algae - phytoplankton. The total abundance and biomass of planktonic algae ranged 0.45-1584.21 mln.cells/l and 0.44-109.35 mg/l. The algae, quantitavely dominating in the phytoplankton, are those of phylum *Cyanophyta,Chlorophyta,Dinophyta*and class *Bacillariophycea.* In 2015, the level dynamics in the reservoir was high and stable, close to the normal headwater level - 53 m, resulting in quite short and not so intense phenomenon of "blooming" water as can be seen usually in the summer and summer-autumn period in Kuibyshev reservoir. During the study, the coefficients of Spierman correlation between the indices of phytoplankton, air temperature, water temperature and water level fluctuation were calculated, and some relations were found. A negative correlation (*r*= -0.65 at *p*<0.05) was observed between the quantitative indices of phytoplankton (the total abundance and biomass) and the water level. Together with the decline in water level an increase in the content of the blue-green algae was observed (*r*= -0.7 both for abundance and biomass at *p*<0.05). No significant correlations between water temperature, air temperature and the indicators of algal communities were observed. The results of this study will be used in the monitoring and forecasting research of the rivers of the Republic of Tatarstan.

Keywords: phytoplankton, algae, blue-green algae, Kuibyshev reservoir, the Volga River, water level.

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ISSN: 0975-8585

INTRODUCTION

The Kuibyshev reservoir (Republic of Tatarstan, Russia) was formed as a result of the river Volga stanching with a dam of the Volga hydroelectric station near the city of Togliatti and designed for seasonal flow regulation. The length of the reservoir from the Cheboksary to Kuibyshev hydroelectric complex is 480 km along the Volga river and 201 km along the Kama river. A characteristic feature of the reservoir banks is a pronounced asymmetry of the Volga valley. The Volga Upland (the Tetyush, Undor and Sengiley mountains of 200-250 m high) and rocky Zhiguli Mountains strech along the right bank. The left bank is mostly flat and low-lying.

The large difference between the right and left banks causes the differing hydrological conditions along the reservoir. These are various depths, discharge and wind currents, wind-induced phenomena, as well as height and strength of waves, which affect the living conditions of aquatic organisms, and especially planktonic algae - phytoplankton.The data on the structure and the production characteristics of phytoplankton as primary producer reveal the features of the organization and the status of aquatic ecosystems. Since the Kuibyshev reservoir is of great water economic and industrial importance, it is extremely relevant for our country to implement the monitoring over changes in the state of aquatic organisms in this reservoir.

Despite the fact that currently the study of the Volga phytoplankton has become the subject of numerous publications [1-8], the patterns of development and distribution of planktonic algae in the Volga reservoirs are still half studied.

Objective of this paper was to determine seasonal dynamics and spatial distribution patterns of planktonic algae in the right bank of the Kuibyshev reservoir.

MATERIALS AND METHODS

A weekly sampling of phytoplankton of the Kuibyshev reservoir (the Volga river), near the village Shelanga was carried out during the growing season (June-September) of 2015 (Fig. 1).

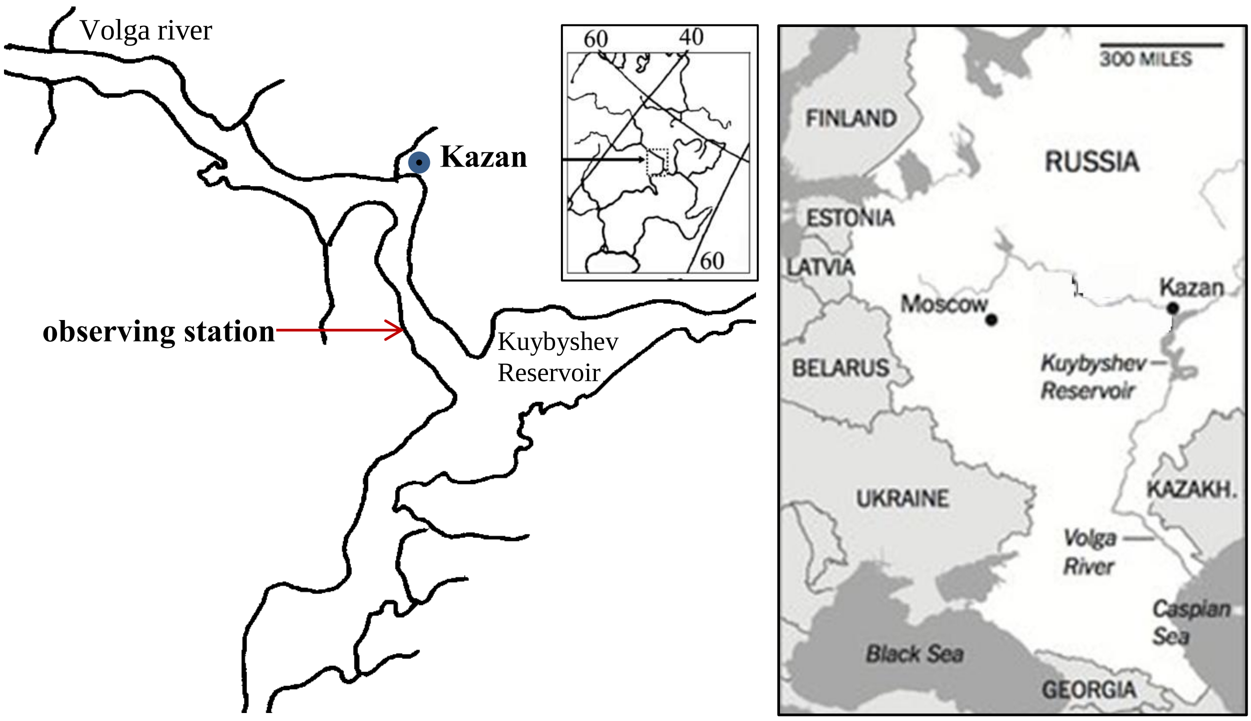


Fig. 1. Location map of the study area of the Volga reach of the Kuibyshev reservoir (vil. Shelanga, 2015)

Water sampling was carried out from the shore at a depth of 1.5 m. Selection and office processing of phytoplankton samples were carried out according to standard methods [9], [10]. Total 29 quantitative and 26 qualitative samples of planktonic algae were collected. In the study period we recorded weather conditions and air temperature. When sampling, the temperature and transparency were measured with Secchi disk.

The algal communities were characterized by their species composition, abundance and biomass. We calculated trophic index according to the Milius block for each sample: Ib = 44.87+23.22*logB [11], the Pantle–Buck saprobity index modified by Sladecek for planktonic communities [12]. Correlation analysis between the algocoenosis indices and other data was performed using the Spearman test, $p<0.05$. To characterize the structural indicators of phytoplankton communities we studied dynamics of overall and relative species abundance. Species with abundance or biomass greater or equal to 10% of total rate were dominant in the communities, and 5-10% were subdominant. Dominating complexes are allocated based on the function of rank distribution in terms of species abundance and biomass.

RESULTS

During the observation period, 75 taxa were found in the phytoplankton of the studied site (Table 1). Species diversity is low because the applied research methodologies were for planktonic algae study only. The greatest number of taxa was found in the class *Bacillariophyceae* (39.53%) and the phylum *Chlorophyta* (36.05%) (Fig. 2). Other groups were less diverse: *Cyanophyta* – 9.30%, *Euglenophyta* – 5.81%, *Chrysophyceae* – 3.49% abd *Dinophyta* – 3.49%.

Species diversity of phytoplankton ranges throughout the study period from 22 to 4 species per sample. The highest occurrence rate is typical of species of the classes *Cyanophyceae, Bacillariophyceae, Chlorophyceae*and*Dinophyceae.*

Table 1. Main systematic groups of algae of phytoplankton of the Volga reach of the Kuibyshev reservoir (vil. Shelanga, 2015)

Phylum	Class	Order
Cyanophyta	Cyanophyceae	*Chroococcales*
		Oscillatoriales
		Nostocales
Cryptophyta	Cryptophyceae	*Cryptomonadales*
Dinophyta	Dinophyceae	*Peridiniales*
		Gonyaulacales
	Chrysophyceae	*Chromulinales*
Ochrophyta	*Bacillariophyceae*	*Thalassiosirales*
		Melosirales
		Fragilariales
		Tabellariales
		Naviculales
		Achnanthales
		Cymbellales
		Surirellales
Euglenophyta	Euglenophyceae	*Euglenonales*
Chlorophyta	Chlorophyceae	*Chlamydomonadales*
		Volvocales
		Sphaeropleales
Charophyta	Zygnematophyceae	*Desmidiales*

ISSN: 0975-8585

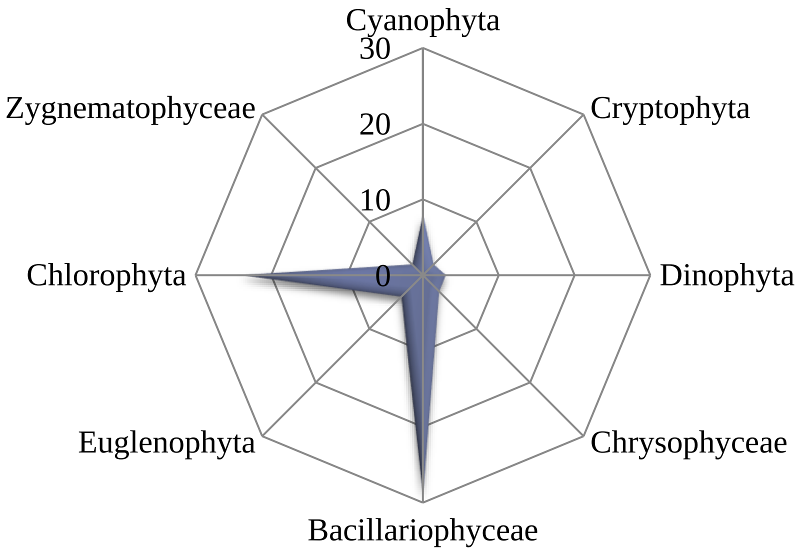
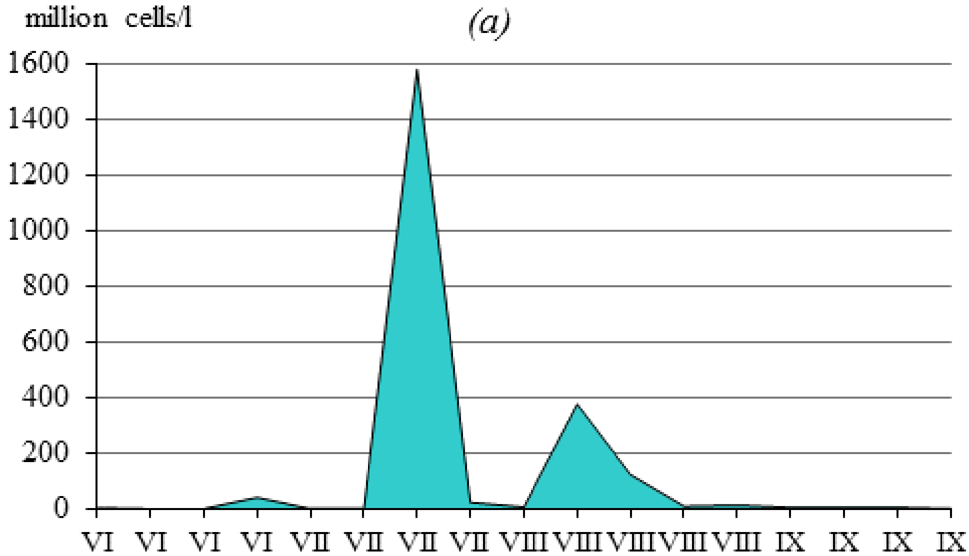


Fig. 2. Distribution of taxa of phytoplankton of the Kuibyshev reservoir (vil. Shelanga, 2015)

Cosmopolitan (52 species) and planktonic (29 species) species of algae prevailed by environmentally-geographical characteristics. In relation to halobility, most species are indifferent (47 species), and in terms of pH the most common are the indifferent (29 species) and alkaliphile + alkalibiontic algae (18 species).

DISCUSSION

The total abundance and biomass of planktonic algae ranged 0.45-1584.21 mln.cells/l and 0.44-109.35 mg/l (Fig. 3, 4). The algae, quantitavely dominating in the phytoplankton, are those of phylum *Cyanophyta Microcystis aeruginosaf. flos-aquae* (Wittr.) Elenk., *Anabaena flos-aquae* Breb., *Anabaena scheremetievi* Elenc., *Aphanizomenon flos-aquae* (l.) Ralfs., *Oscillatoria* sp., *Oscillatoria planctonica*Wotosz., класса *Bacillariophycea Melosira varians* Ag., *Aulacoseira italica* (Ehr.) Kiitz., *Stephanodiscus hantzschii* Crun., *Nitzschia palea* (Kiitz).W.Sm., *Diatoma vulgare* Bory., *Navicula* sp. sp., phylum *ChlorophytaCarteria globosa* Korschik., *Chlamydomonas* sp., *Pandorina morum* (Mill.) Bory., *Scenedesmus guadricauda* (Turp.) Breb. and phylum *DinophytaPeridiniumcinctum* (O.F.M.)Ehr.



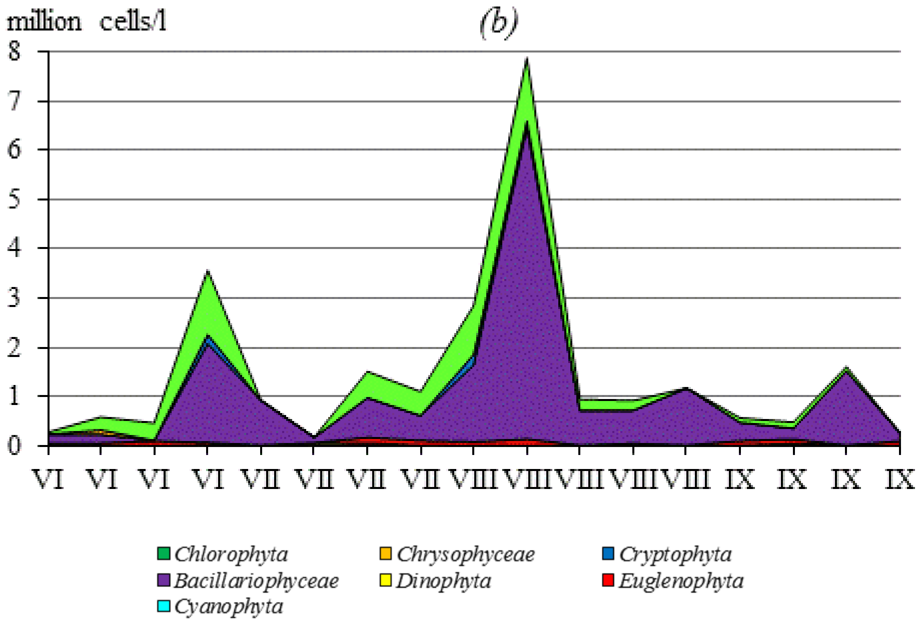


Fig. 3. Seasonal dynamics of the abundance of individual groups of phytoplankton (million cells/l) in the Kuibyshev reservoir (vil. Shelanga, 2015): *a* - *Cyanophyta*, *b* - other groups of phytoplankton.

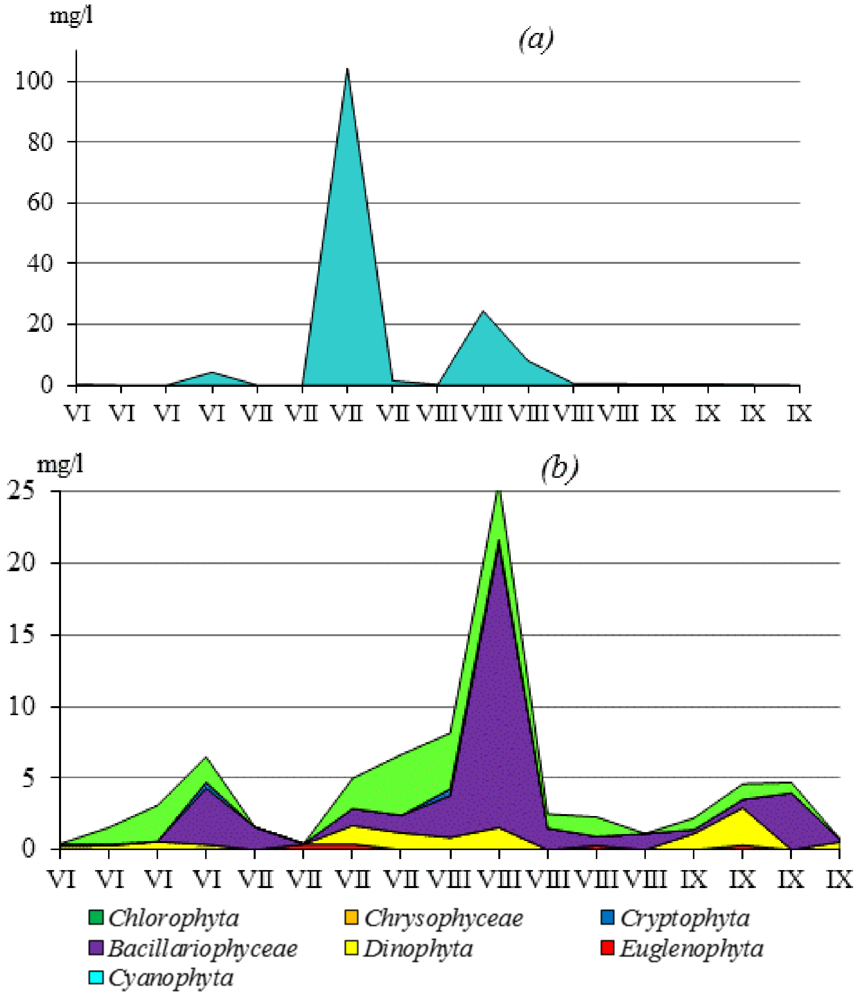


Fig. 4. Seasonal dynamics of the biomass of individual groups of phytoplankton (mg/l) in the Kuibyshev reservoir (vil. Shelanga, 2015):
***a* – *Cyanophyta*, *b* – other groups of phytoplankton.**

After ranking the species descending the quantitative value for each species, we obtained the dominance curves (Fig. 5), allowing us to estimate the role of a certain species in phytoplankton coenosis. The dominance index increases together with water trophicity as durin the change of aqueous medium from the meso-oligotrophic to meso-eutrophic, the simplification of the phytoplankton structure is observed with the increasing domination of individual species. The relation between the dominance index and trophic status (TSI) is statistically significant (r = 0.75, p <0.05).

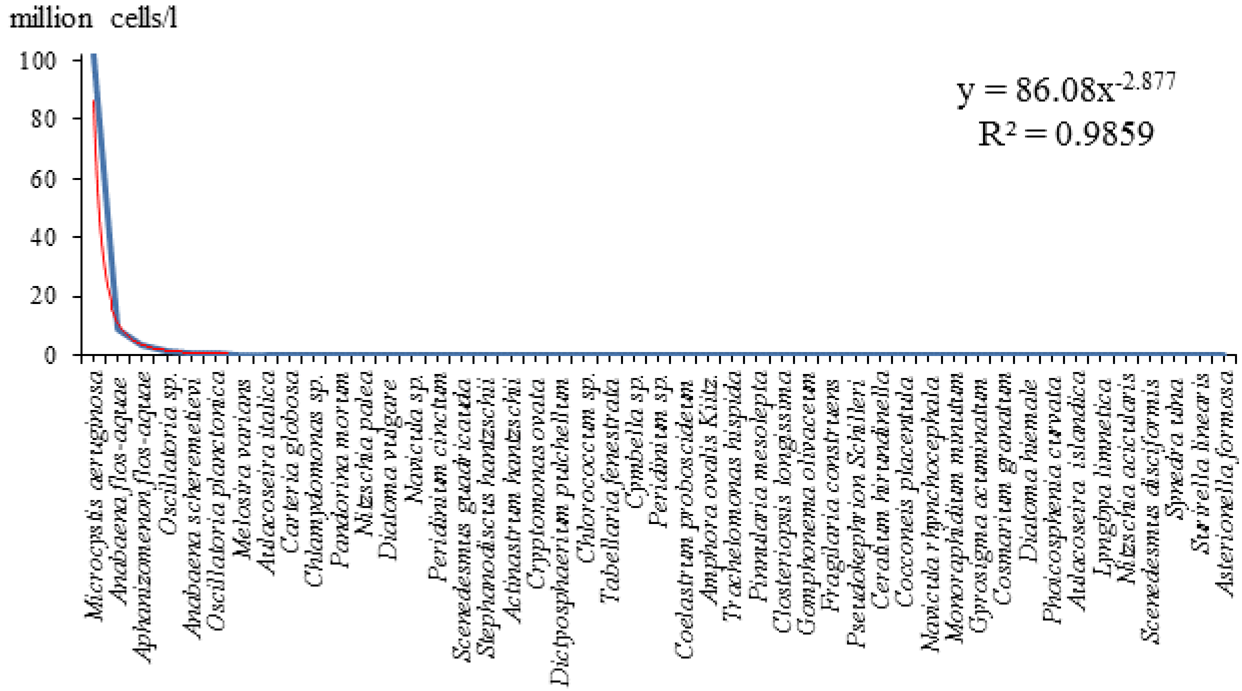


Fig. 5. Distribution of the average abundance (mln.cl/l) of the dominant species of planktonic algae in the Kuibyshev reservoir (vil. Shelanga, 2015)

Seasonal dynamics of phytoplankton in 2015 was slightly uncommon to this reservoir [13], [14], which was due to the weather conditions of this year and the dynamics of the level regime in the reservoir. Spring processes in 2015 started actively and rapidly. May and June were very warm and dry, resulting in bloom of blue-green algae in the end of June.

Seasonal dynamics of phytoplankton of all sites involved two peaks of abundance and biomass - in the third decade of July and in the second decade of August. While the first maximum of phytoplankton growth was due to the mass development of blue-green algae, which caused "bloom" of water, the second peak was characterized by a set of phytoplankton of blue-green, green algae and diatoms. July and August were rainy (150% and 120% of normal). The widespread and stormy rains lasted 20 days in July.

One of the main features of the Kuibyshev reservoir is high amplitude of seasonal fluctuations in water level [15]. We have obtained data on the water level in the reservoir in hydrochemical laboratory FSI “Sredvolgavodkhoz”, which continuously monitors hydrochemical parameters at the Kuibyshev and Nizhnekamsk reservoirs.

The dynamics of the water level during the studied year was very different from previous years. By the end of previous summer 2014, the water level was extremely low in September and October, and the Kuibyshev reservoir stayed for the winter with very low water level, plus it wore out during the winter, and shallowed completely. In 2015, in the first half of the summer, the water level was close to normal - 53 m, with small fluctuations caused by wind-induced phenomena. July 24 untill August 9, 2015, the World Championship in water sports took place in Kazan. In order to stabilize the water level in the Kazanka river (which is one of the main tributaries of the Kuibyshev neservoir near the city of Kazan), at the time of the Championship a special operation conditions of Zhiguli and Volgograd hydroelectric complex were established by the decision of the Division for Water Resources of RT, of the Lower Volga Basin Water Management and the Federal

ISSN: 0975-8585

Agency for Water Resources of the Russian Federation. In addition, as mentioned above, July and August were extremely rainy. In 2015, the level dynamics in the reservoir was high and stable, close to the normal headwater level - 53 m. In the middle of the summer there was a short-term decline and rise again, which lasted until the autumn.

Decrease in water level, usual for the Volga reservoirs [16], leads to outbreak in the algal abundance and biomass. This year, the phenomenon of "blooming" water was short-term and not so intense as can be seen usually in the summer and summer-autumn period in Kuibyshev reservoir.

Indicators of quantitative development of phytoplankton are widely used to characterize the state and trophic status of water bodies. According to the results, the water of the study area was mostly of mesotrophic type during the period of observation. Water quality was assessed as β-meso-saprobic, moderately polluted; quality class III (Fig. 6).

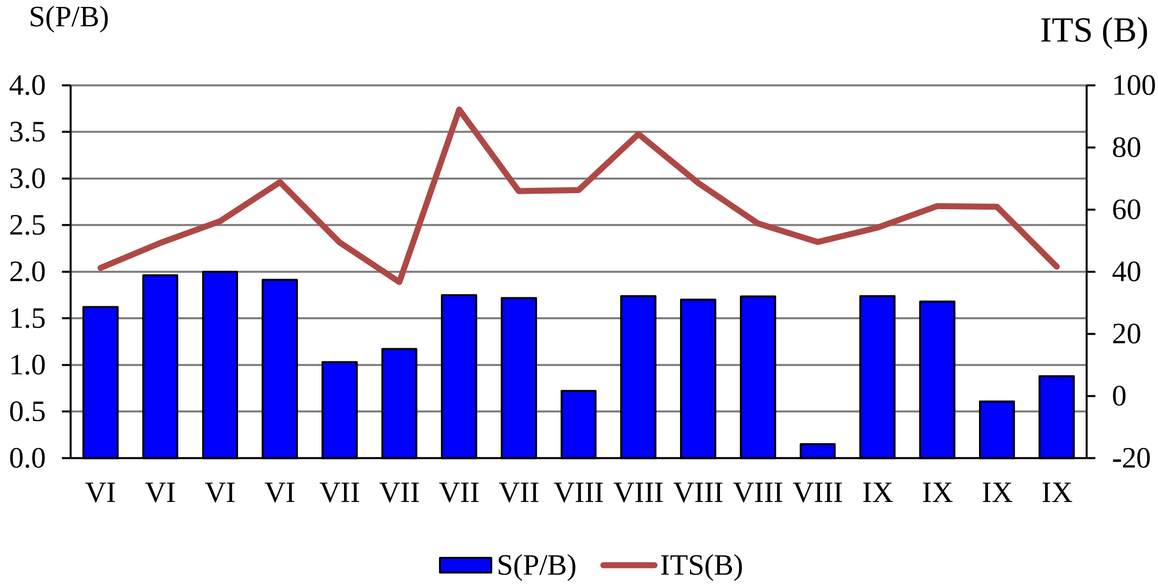


Fig. 6. Dynamics of the trophic indices (ITS) and saprobity by biomass (S) of phytoplankton of the Kuibyshev reservoir (vil. Shelanga, 2015).

SUMMARY

During the study, the coefficients of Spierman correlation between the indices of phytoplankton, air temperature, water temperature and water level fluctuation were calculated, and some relations were found. A negative correlation (r= -0.6 and -0.7 at p<0.05) was observed between the quantitative indices of phytoplankton (the total abundance and biomass) and the water level. Together with the decline in water level an increase in the content of the blue-green algae was observed (r= -0.7 both for abundance and biomass at p<0.05). We also observed an increase in the concentration of dinophyte algae at higher air temperature (r= 0.6 and 0.7 at p<0.05). Neither air temperature nor water temperature had any significant influence on the content of algae of other groups. Such relations in nature generally have a cause-and-effect, indirect character.

CONCLUSION

Studying the biology and structure of phytoplankton communities in the aquatic ecosystems is the basis for monitoring and quality control of natural water. The results of this study will be used in the monitoring and forecasting research of the rivers of the Republic of Tatarstan.

ACKNOWLEDGEMENTS

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

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