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Article

Phytoplankton of the middle course of the Kostroma River and its tributaries (Kostroma Oblast, Russia)

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Abstract. This study was undertaken in the summer and fall of 2009–2013 to investigate phytoplankton in the middle reaches of the Kostroma River and its first-order Koryoga and Tyobza tributaries. Based on the analysis of floral and species diversity, the ratio of large taxonomic groups (divisions), dominant species, abundance, biomass and phytoplankton cell size, as well as chlorophyll a content and water saprobity, both similarities and differences were found in the phytoplankton of the rivers and the quality of their waters. It was also found that the diversity and abundance of the river phytoplankton was determined by green algae, diatoms and cyanoprokaryotes. It was shown that in the tributaries (small rivers) the diversity and abundance of phytoplankton, as well as the level of water trophy, decreased. The latter was accompanied by an increase in the proportion of mixotrophic phytoflagellates in the potamoplankton of the Koryoga and Tyobza rivers. At the same time, the algae cell size in the tributaries increased. The water saprobity in all the rivers corresponded to the β-mesosaprobic zone of organic pollution. The water quality assessment based on various indicator parameters of phytoplankton showed that the rivers under study belonged to two classes: clean and satisfactory clean, with higher water quality in the tributaries.

Keywords: planktonic algae, diversity, biomass, abundance, chlorophyll a, saprobity, water quality, Koryoga River, Tyobza River

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Научная статья

Фитопланктон среднего течения р. Кострома и ее притоков (Костромская область, Россия)

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Аннотация. Летом и осенью 2009–2013 гг. исследовали фитопланктон среднего течения р. Костромы и ее притоков первого порядка Корёга и Тёбза. На основании анализа флористического и видового разнообразия, соотношения крупных таксономических групп (отделов), доминирующих видов, численности, биомассы и размерности клеток фитопланктона, а также содержания хлорофилла а и сапробности вод обнаружены как сходства, так и различия фитопланктона рек и качества их вод. Установлено, что разнообразие и обилие фитопланктона рек определяли зеленые, диатомовые водоросли и цианопрокариоты. Показано, что в притоках (малых реках) разнообразие и обилие фитопланктона, а также уровень трофии вод снижались. Последнее сопровождалось увеличением пропорции в потамопланктоне рек Корёга и Тёбза обилия миксотрофных фитофлагеллят. При этом размерность клеток водорослей в притоках увеличивалась. Сапробность вод во всех реках соответствовала β-мезосапробной зоне органического загрязнения. Оценка качества вод по различным индикаторным показателям фитопланктона показала, что реки относились к двум классам: чистым и водам удовлетворительной чистоты, причем более высоким качеством отличались воды притоков.

Ключевые слова: планктонные водоросли, разнообразие, биомасса, численность, хлорофилл а, сапробность, качество вод, река Корёга, река Тёбза

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Introduction

The current scale of anthropogenic impact leads to a disruption in the hydrological and hydrochemical regimes of water bodies and watercourses, an increase in the circulation of organic and mineral substances, which eventually causes changes in the quality of water resources. Recent climate change has also contributed to these processes. Small rivers are particularly sensitive to natural and anthropogenic impacts (Ekosistema maloi reki..., 2007). In the European part of the Russian Federation, the regime and feeding of medium and small lowland rivers is determined by the temperate continental climate. Diffuse runoff from catchment areas saturated with suspended matter and various chemicals, during snowmelt and precipitation, may to a large extent cause the transformation of aquatic ecosystems. Currently, in the European part of Russia, there are practically no catchment areas which are not subject to anthropogenic impacts. Human waste discharge from watersheds contributes to rapid deterioration of the quality of inland waters. However, diffuse pollution is not monitored or regulated by any environmental agency (Yasinskii et al., 2020). Therefore, over the past decades, scientific interest in estimating the diffuse substance inputs from catchment areas into water bodies of the Russian Federation has increased significantly (Yasinskii et al., 2007, 2019, 2020). For example, the contribution of landscapes to the diffuse runoff on the left bank of the Cheboksary Reservoir is found to be ~ 90% (Yasinskii et al., 2020).

Small and medium-sized rivers account for more than 95% of the hydrographic network of the Russian Federation, and over 50% of the total river flow is formed in their basins (Tkachev and Bulatov, 2002). Nevertheless, they still remain the most poorly studied in terms of their hydrology, hydrochemistry and biology.

Phytoplankton is a key component of aquatic ecosystems, which performs the most important function – the synthesis of primary organic matter. To conduct environmental monitoring, it is first necessary to know the current composition of phytoplankton and dynamics of its quantitative characteristics in small lowland rivers, which are affected by catchment characteristics in the first place. The phytoplankton in tributaries of Europe's largest river, the Volga, and especially in medium and small rivers of the Upper Volga basin, has been studied extremely poorly, (Frolova, 2004; Komissarov, 2017; Sakharova, 2017). Small and medium-sized rivers of the left bank of the Gorky Reservoir, in particular the large left-bank tributary of the Volga River – the Kostroma River and its two tributaries – the Koryoga and Tyobza rivers, have so far remained insufficiently studied in terms of algology.

The aim of this study is to assess the phytoplankton population and the water quality in the middle courses of the Kostroma, Koryoga and Tyobza rivers.

Material and methods

The Kostroma River flows through the Chukhloma, Soligalich, Bui and Kostroma districts of the Kostroma Oblast and enters the Gorky Reservoir, forming the Kostroma extension (Kostroma Bay) in its mouth. The water in the Kostroma River, both in its middle and lower reaches, belongs to the bicarbonate class, the calcium group, and the second type (Kochetkova, 2009). In 2019, the total phosphorus content in the Kostroma River near the town of Bui, where the Hydrological Observation Post and Meteorological Station are located, ranged from 0.082 to 0.252 mg/l[1]. Such concentrations of phosphorus are typical for eutrophic-hypertrophic waters (Kitaev, 2007). The length of the Kostroma River is 354 km, its watershed is 16000 km^2. In its middle course, below the town of Bui, two tributaries flow into the river –

[1] Report on the environmental situation in the Kostroma oblast in 2019, 2019. Web page. URL: https://www.ecoindustry.ru/gosdoklad/view/620.html (accessed: 28.11.2023).

the Koryoga River and the Tyobza River. The Koryoga is the right-bank tributary of the first order, flowing through the Bui raion of the Kostroma oblast. It is 62 km long and has a catchment area of 409 km^2. The Tyobza is the left tributary of the Kostroma River with a length of 140 km and a basin area of 1160 km^2. According to the catchment area, the Kostroma is a medium-sized river, and its tributaries are small ones. Like most rivers in the Kostroma Oblast, the Kostroma, Koryoga and Tyobza rivers are lowland in nature, have a small slope and a low flow velocity. They have not been studied in terms of algology. The only phytoplankton data from the Kostroma extension, where waters of over a dozen different tributaries mix, including the Kostroma River, was obtained in 1992 (Korneva and Soloveva, 2000).

Phytoplankton samples were collected in June 2009, July 2010, 2012 and October 2011, 2013 with a Ruttner bathometer from 0 m to near bottom layer at 13 stations (Fig. 1). Of these, 6 stations were located in the middle reaches of the Kostroma River, upstream and downstream of the town of Bui, where the backwater of the Gorky Reservoir begins to take effect, 4 – on the Koryoga River and 3 – on the Tyobza River. For further quantitative analysis, the phytoplankton samples were concentrated by direct filtration of water under pressure sequentially through membrane filters with a pore diameter of 5 and 1.2 μm. The samples were condensed to a volume of 5 ml and fixed in Lugol's solution with the addition of formalin and glacial acetic acid (Metodika..., 1975). Algal cells were counted under NU-2 (Carl Zeiss Jena, Germany) and MBB-1A (LOMO, St. Petersburg) light microscopes in the "Uchinskaya-2" counting chamber (volume 0.01 and 0.02 ml). The standard counting-volumetric stereometric method (Metodika..., 1975) was used to determine the biomass. To assess the species diversity of algocenoses, we used the number of algal taxa below the rank of genus in a sample (specific richness) and cenotic diversity (Shannon index) (Pesenko, 1982). Species which constituted ≥ 10% of the total abundance and biomass of phytoplankton were considered dominant. The water saprobity was assessed using the Pantle–Buck index (Pantle and Buck, 1955) modified by V. Sladechek (Sladechek, 1973). Species were confined to particular zones of saprobity according to the lists of indicator organisms by V. Sladecek (Sladecek, 1973) with additions by R. Wegl (Wegl, 1983). In the annotated list of algae, the divisions were arranged according to the botanical classification adopted in the 4-volume edition of "Algae of Ukraine" (Borisova et al., 2000) and in the serial publication "Süßwasserflora von Mitteleuropa". Data on the ecology and distribution of species and intraspecific taxa were taken from floristic and systematic summaries and individual publications (Korneva, 2015).

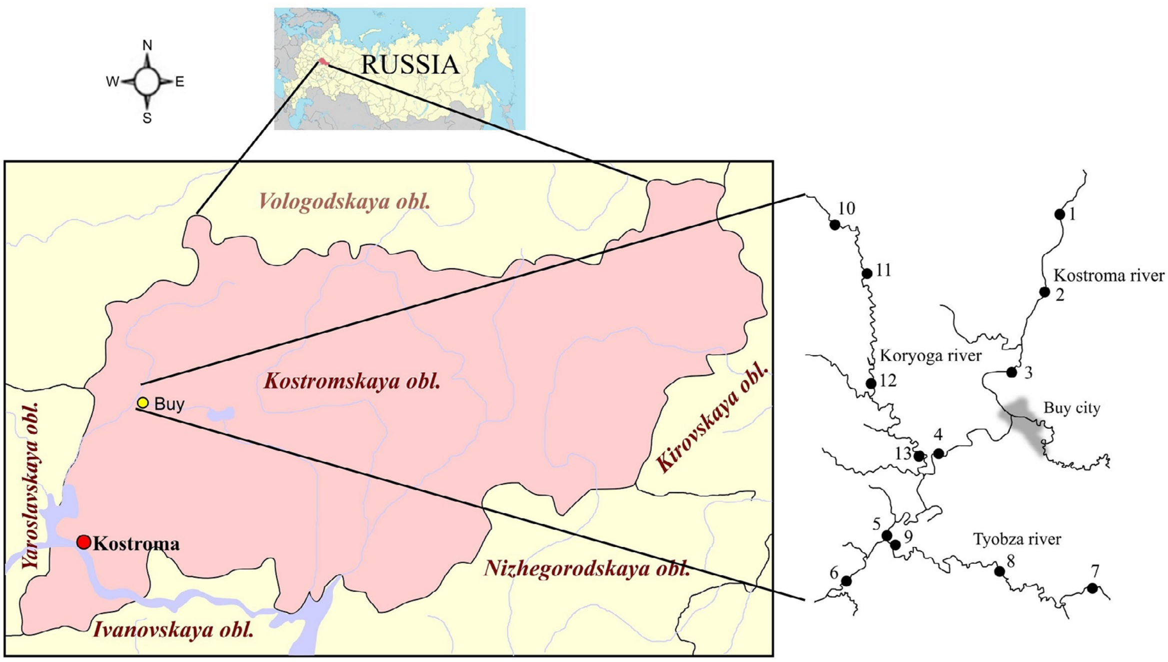

Fig. 1. The locations of sampling stations: 1–6 – Kostroma River, 7–9 – Tyobza River, 10–13 – Koryoga River.

To analyze the pigment content of phytoplankton, water samples were concentrated on membrane filters with a pore diameter of 5 μm (Mineeva, 2004) with a pre-applied substrate of powdered glass and chalk (Metodika..., 1975). The analysis was carried out using a Lambda 25 spectrophotometer (Perkin Elmer, USA) in a mixed 90% acetone extract (Determination..., 1966; Lorenzen, 1967).

The flow velocity of the rivers was determined at each station by measuring the speed of a float in the surface water layer, depth – using a handheld lead line marked in intervals of 50 cm, transparency – using a Secchi disk, electrical conductivity of water and concentration of dissolved oxygen – using a portable device "YSI Model 777" ("YSI Inc.", USA).

The water quality in the rivers under study was assessed according to the comprehensive ecological classification of the quality of land surface waters (Zhukinsky et al., 1981).

Results and discussion

During the study period, the average flow velocity, depth, water transparency, electrical conductivity and oxygen content varied slightly between the rivers (Table 1). The river banks were covered with herbaceous and shrubby vegetation, the bottom – with a mixture of sand, gravel, clay and plant debris.

A total of 466 species, varieties and forms of algae, represented by eight divisions, were found in the plankton flora of the rivers (Table 2). During all the periods of observation, green algae, diatoms

Table 1. Characteristics of the rivers under study.

Characteristic	River		
	Kostroma	Koryoga	Tyobza
Width, m	30–50	8–15	8–15
Depth, m	0.9–1.9	0.7–1.4	1.0–2.3
Current speed, m/s	0.17–0.34	0.12–0.14	0.10–0.15
Secchi disk transparency, m	0.6–1.0	0.6–1.1	0.6–1.0
Conductivity, μS/cm at 25 °C	277–488	328–516	246–415
Oxygen, mgO_2/l	6.4–11.4	7.2–11.3	6.0–11.1

Table 2. The number of species, varieties and forms in different divisions of algae in the plankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Division	Sampling date					Total
	5–7.VI. 2009	3–4.VII. 2010	20.X. 2011	25–27.VII. 2012	30–31.X. 2013	
Cyanoprokaryota	45	45	65	55	11	80
Chrysophyta	9	7	13	6	2	14
Bacillariophyta	40	31	65	53	15	69
Xanthophyta	5	0	0	1	0	5
Cryptophyta	6	6	9	14	5	9
Dinophyta	5	6	2	11	0	11
Euglenophyta	22	25	15	20	4	40
Chlorophyta	127	137	139	149	38	238
Total	**259**	**257**	308	309	75	466

and cyanoprokaryotes were characterized by the greatest species richness. The algal flora of the rivers was formed mainly by cosmopolitans (95%), obligate plankters (51%), species indifferent to changes in water salinity (78%) and pH (71%), and β-mesosaprobes (49%) in relation to the content of easily digestible organic matter.

The highest specific richness of phytoplankton was observed in the Kostroma River; its average value ranged from 22 ± 1 to 91 ± 5 taxa below the rank of genus in a sample (Table 3). In the Koryoga and Tyobza tributaries, this indicator decreased by ~ 2 times and varied from 10 ± 2 to 68 ± 16 and from 15 to 57 taxa, respectively. Phytoplankton richness of the Kostroma River in summer (June, July) was formed by green algae > cyanoprokaryotes > diatoms, in autumn (October) – by green algae > diatoms > cyanoprokaryotes; of the Koryoga River in summer – by green algae > diatoms, in late spring and autumn – by diatoms > green alae; of the Tyobza River – by diatoms > green algae (Fig. 2).

The Kostroma River phytoplankton was also characterized by the greatest cenotic diversity (Table 3), which decreased by 1.2–1.4 times in the river tributaries. A reduction in the species diversity

Table 3. The average specific richness and cenotic diversity of phytoplankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Date	River					
	Kostroma	Koryoga	Tyobza	Kostroma	Koryoga	Tyobza
	Specific richness			Shannon diversity index		
5–7.VI.2009	89 ± 3	45 ± 4	30 ± 2	5.03 ± 0.08	4.24 ± 0.22	1.71 ± 0.15
3–4.VII.2010	85 ± 7	68 ± 16	50	4.75 ± 0.14	3.98 ± 0.39	3.18
20.X.2011	91 ± 5	49 ± 1	31	4.52 ± 0.16	3.44 ± 0.33	3.34
25–27.VII.2012	75 ± 5	57 ± 2	57	4.42 ± 0.27	4.01 ± 0.31	4.27
30–31.X.2013	22 ± 1	10 ± 2	15	3.00 ± 0.16	2.14 ± 0.13	2.65

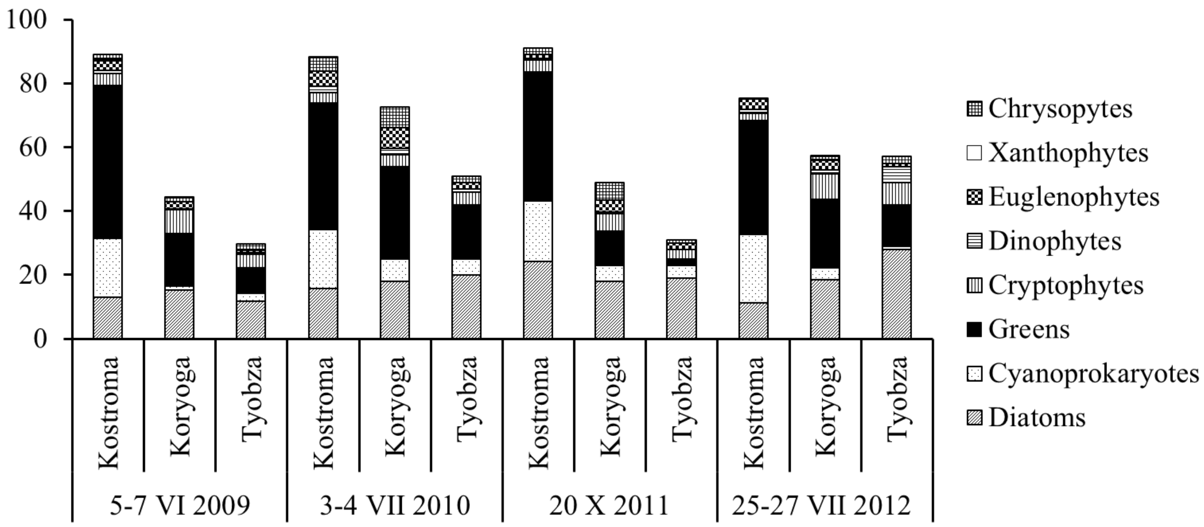

Fig. 2. The specific richness of various groups of algae in the plankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

of phytoplankton with decreasing size of the water body, i.e. its relationship with morphometry, was observed in lakes (Zagorenko, 1987) and reservoirs (Korneva, 2015) while basic physico-chemical parameters of the aquatic environment varied only slightly.

The highest values of the phytoplankton total abundance and biomass (Table 4, Fig. 3, 4), as well as concentrations of the main photosynthetic pigment chlorophyll *a* (Table 5), were also characteristic of the Kostroma River. The saprobity index values varied slightly between the rivers and averaged ~ 2, which corresponds to the β-mesosaprobic zone of organic pollution.

The ratio of phytoplankton abundance to biomass was always significantly ($p < 0.05$) higher in the Kostroma River (Table 6) indicating that the potamoplankton of the river was represented by smaller algal species. A similar phenomenon is observed in lakes, reservoirs and rivers as their trophic state increases (Korneva, 2015; Mikheeva, 1992; Okhapkin, 2002). The average size of algal cells increased

Table 4. The average abundance and biomass of phytoplankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Date	River					
	Kostroma	Koryoga	Tyobza	Kostroma	Koryoga	Tyobza
	Abundance, million cells/l			Biomass, g/m^3		
5–7.VI.2009	152 ± 19	1.48 ± 0.46	0.70 ± 0.20	3.21 ± 0.14	0.44 ± 0.08	0.76 ± 0.11
3–4.VII.2010	55 ± 11	26 ± 22	0.90	3.57 ± 0.69	2.22 ± 1.26	0.69
20.X.2011	40 ± 5	0.33 ± 0.08	0.10	1.65 ± 0.15	0.28 ± 0.06	0.22
25–27.VII.2012	397 ± 48	0.75 ± 0.12	0.60	5.78 ± 0.51	0.48 ± 0.04	0.75
30–31.X.2013	12 ± 3	0.09 ± 0.06	0.07	0.32 ± 0.06	0.16 ± 0.10	0.01

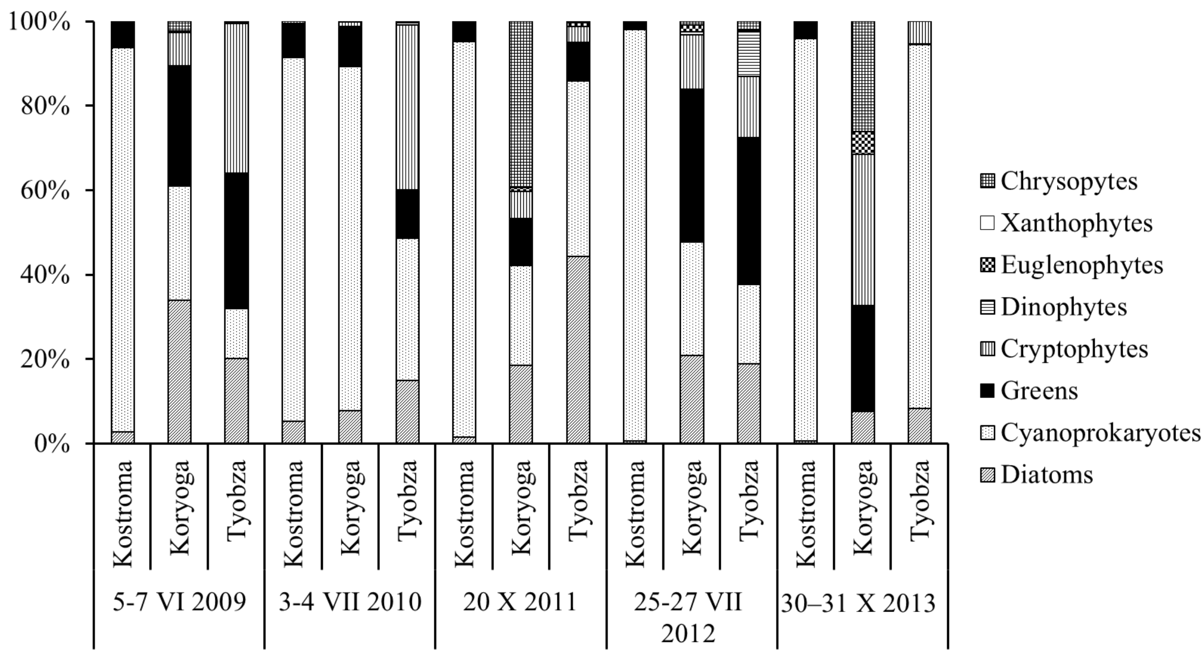

Fig. 3. The ratio of the abundance of particular taxonomic groups of phytoplankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

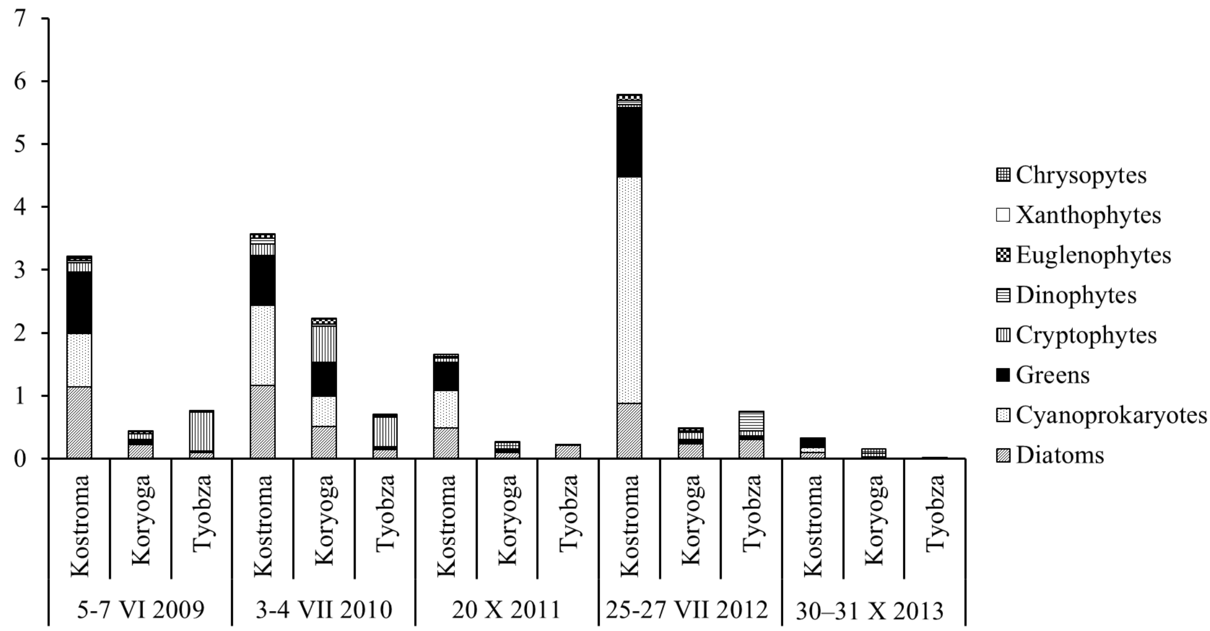

Fig. 4. The phytoplankton biomass of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Table 5. The average chlorophyll a content in water and saprobity indices of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Date	River					
	Kostroma	Koryoga	Tyobza	Kostroma	Koryoga	Tyobza
	Chlorophyll *a*, мкг/л			Saprobity index (by biomass)		
5–7.VI.2009	16.5 ± 0.7	4.4 ± 1.3	3.1 ± 0.4	1.96 ± 0.01	2.10 ± 0.03	1.87 ± 0.02
3–4.VII.2010	1.6 ± 0.31	0.9 ± 0.3	0.4	1.95 ± 0.04	2.27 ± 0.18	1.84
20.X.2011	9.4 ± 1.4	3.0 ± 0.6	3.0	1.97 ± 0.05	2.06 ± 0.08	2.25
25–27.VII.2012	41.3 ± 2.4	7.6 ± 4.1	3.1	1.85 ± 0.04	2.13 ± 0.08	2.13
30–31.X.2013	8.9 ± 1.2	13.0 ± 4.21	3.7	1.97 ± 0.03	1.96 ± 0.05	2.08

Table 6. The average ratio of phytoplankton total abundance to biomass (× 10−3) of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Date	River		
	Kostroma	Koryoga	Tyobza
5–7.VI.2009	47 ± 25	3 ± 1	0.9 ± 0.1
3–4.VII.2010	15 ± 1	6 ± 3	9
20.X.2011	23 ± 2	1.2 ± 0.1	0.5
25–27.VII.2012	78 ± 14	1.6 ± 0.3	0.9
30–31.X.2013	34 ± 8	0.65 ± 0.03	7.3

significantly in the Koryoga and Tyobza with decreasing phytoplankton abundance, biomass and chlorophyll *a* content.

During the entire study period, the total phytoplankton abundance of the Kostroma River was formed mainly by cyanoprokaryotes (86–98%) (Fig. 3). In the Koryoga River, cyanoprokaryotes (24–82%), green (9–36%) and diatom algae (8–34%) were the most numerous; while dinophytic (up to 41%), golden (up to 39%) and cryptophytic (up to 36%) algae co-dominated in some periods. In the Tyobza River, cyanoprokaryotes (12–86%), diatoms (8–44%), green (9–35%) and cryptophytic (4–39%) algae made up the main proportion of phytoplankton abundance.

The total phytoplankton biomass in the Kostroma River was formed mainly by cyanoprokaryotes, diatoms and green algae (Fig. 4, Table 7), in the Koryoga River – by diatoms, cryptophytes and green algae, and in October 2013 – by cryptophytes, golden algae and euglenoids. In the Tyobza River, diatom and cryptophytic algae accounted for most of the total phytoplankton biomass. In general, the analysis of abundance, biomass and composition of the dominant phytoplankton species showed that in the tributaries the abundance and diversity of various groups of phytoflagellates (cryptophytic, golden, euglenic, dinophytic algae) was significantly higher, compared to the Kostroma River. These algae are capable of a mixed type of nutrition (heterotrophs through phagotrophy and autotrophy), common under conditions of light limitation and lack or poor availability of mineral nutrients in water (Olrik, 1998). Under equal conditions of water depth and transparency in the studied rivers, the increase in the phytoflagellate abundance could be due to improved conditions of heterotrophic nutrition, i.e. an increase in the number of bacterioplankton. Because of the increased role of this functional group of algae in the plankton community, the importance of the obligate autotrophic link, capable of performing photosynthesis, decreased. This can explain the reduced level of water trophy in the tributaries, since it is determined primarily by the primary organic matter production. An increase in the abundance and diversity of mixotrophic phytoflagellates was also observed in most large lowland reservoirs of the Volga basin (Korneva, 2015), in particular, in the left-bank tributaries of the Cheboksar Reservoir (Kulizin et al., 2021). This fact is considered as a sign of the initial stage of the heterotrophic phase of plankton succession, associated with an increase in precipitation and climate humidification in recent decades (Korneva, 2015). In small rivers (in particular, in the Kostroma River tributaries), where the influence of watershed characteristics is most clearly visible, the effects of climate change can be observed first.

According to the trophic state classification of waters based on the average phytoplankton biomass (Kitaev, 2007), the Kostroma is a mesotrophic and its tributaries (Koryoga and Tyobza) are oligotrophic rivers. But according to the concentration of plant pigments (Vinberg, 1960), the Kostroma River is characterized as a eutrophic watercourse, while the Tyobza and Koryoga rivers – as mesotrophic ones. Such a discrepancy (an overestimation of the degree of water trophy in terms of chlorophyll *a* content) is quite common in the scientific literature and may be associated with a decrease in the size of phytoplankton cells in water bodies of a higher trophic status (Korneva, 2015). Therefore, it is preferable to focus on chlorophyll *a* concentrations as an ecological and physiological indicator, since with increasing abundance and decreasing cell size, the phytoplankton biomass changes slightly during eutrophication, while the photosynthetic activity of small-sized cells increases. According to the saprobity index values, all the rivers belonged to the β-mesosaprobic zone of organic pollution.

The water quality in the rivers, assessed using various biological indicators, differed. According to the average values of the saprobity index, used to assess the quality and classify land surface waters (Zhukinsky et al., 1981), the waters of the surveyed sections of the Kostroma River and its tributaries can be referred to Class III of satisfactory quality and categorized as “sufficiently clean”. Bases on the average biomass values, the Kostroma River belongs to Class III of satisfactory water quality and the category of “low polluted”, but the Koryoga and Tyobza rivers – to Class II (clean) and the category of “quite clean”. According to the chlorophyll *a* concentrations, the surveyed sections of the Kostroma River meet Class III requirements of satisfactory water quality and can be categorized as “sufficiently clean”, the Koryoga and the Tyobza rivers belong to Class II (clean) and the category “very clean”.

Conclusion

The potamoplankton flora in the middle reaches of the Kostroma River and in its first-order Koryoga and the Tyobza tributaries is formed mainly by green algae, diatoms and cyanoprokaryotes. The phytoplankton of the Kostroma River is characterized by the highest species richness and cenotic diversity compared to the phytoplankton of its tributaries, which is due to the greater length and larger catchment area of the river. Besides, the phytoplankton of the Kostroma River has the largest biomass, algae abundance, chlorophyll *a* content and the smallest cell sizes, which indicates a higher trophic level of the river water. This is also confirmed by the ratio of large taxonomic functional groups of algae. The total biomass of the Kostroma River phytoplankton is composed mainly of cyanoprokaryotes, diatoms and green algae. The role of various groups of mixotrophic phytoflagellates increases in the plankton of the tributaries. According to chlorophyll *a* concentrations, the Kostroma is characterized as a eutrophic river, and its tributaries (Tyobza and Koryoga) – as mesotrophic watercourses. Based on various biological indicators, the water in the rivers is classified as clean or satisfactory clean (Class II and Class III).

Table 7. Dominant species (% of the total biomass) in phytoplankton of the Kostroma, Koryoga and Tyobza rivers in 2009–2013.

Date	River		
	Kostroma	Koryoga	Tyobza
VI.2009	*Fragilaria berolinensis* (Lemm.) Lange-Bertalot (10–26) *Aulacoseira granulata* (Ehr.) Sim. (11) *Limnothrix redekei* (Goor) Meffert (10–15) *Microcystis flos-aquae* (Wittr.) Kirch. (20) *Pseudopediastrum boryanum* (Turpin) E. Hegewald (13)	*Cryptomonas ovata* Ehr (10) *C. marssonii* Skuja (18) *Navicula radiosa* Kütz. (47) *N. tripunctata* (O.F. Müller.) Bory (18) *Strombomonas tambowica* (Swir.) Defl. (10) *Stephanodiscus hantzchii* Grun. (14) *Chlamydomonas* sp. (10)	*Cryptomonas curvata* Ehr. (72–81)
VII.2010	*Ulnaria acus* (Kütz.) M. Aboal (13–21) *Fragilaria radians* (Kütz.) D.M. Williams et Round (12–31), *Stephanodiscus hantzschii* (11–14) *Aulacoseira granulata* (11) *A. ambigua* (Grun.) Sim. (10–18) *Cyclotella meneghiniana* Kütz. (10) *Dolichospermum planctonicum* (Brunnth.) Wacklin et al. (11–12) *Limnothrix redekei* (11–20) *Pseudanabaena limnetica* (Lemm.) Kom. (11) *Aphanizomenon issatschenkoi* (Ussacz.) Prosch.-Lavr. (11–15)	*Ulnaria acus* (18) *Cyclotella meneghiniana* (10) *Stephanodiscus hantzschii* (12) *Limnothrix redekei* (11) *Cryptomonas* spp. (11–22)	*Cryptomonas* spp. (24–40)
X.2011	*Stephanodiscus hantzschii* (10–13) *Ulnaria ulna* (Nitzsch) P. Compére (12–13) *Aulacoseira ambigua* (12) *Melosira varians* Ag. (13) *Desmodesmus spinosus* (Chod.) E. Hegewald (20) *Mougeotia* sp. (12–30) *Limnothrix redekei* (26–51)	*Melosira varians* (15) *Fragilaria capucina* Desm. (21) *Navicula* sp. (10–14) *Nitzschia* sp. (16) *Synura* cf. *uvella* Ehr. em. Korsch. (13–61)	*Melosira varians* (26) *Nitzschia* sp. (18) *Cymbella* sp. (12) *Gyrosigma* sp. (11)

Date	River		
	Kostroma	Koryoga	Tyobza
VII.2012	*Microcystis wesenbergii* (Kom.) Kom. (17–39) *M. viridis* (A. Braun) Lemm. (16) *M. aeruginosa* (Kütz.) Kütz. (13) *Aphanocapsa holsatica* (Lemm.) Cronb. et Kom. (12–30) *A. incerta* (Lemm.) Cronb. et Kom. (16) *Dolichospermum planctonicum* (11–44) *Dolichospermum flos-aquae* (Lyngb.) Wacklin et al. (32–57) *Aphanocapsa planctonica* (G.M. Sm.) Kom. et Anagn. (10) *Chroococcus limneticus* Lemm. (10) *Dolichospermum* sp. (10–27) *Aulacoseira ambigua* (23)	*Diatoma vulgaris Bory* (20) *Melosira varians* (52) *Cyclotella meneghiniana* (12–16) *Cryptomonos marssonii* (29) *Cryptomonas* sp. (11) *Chlamydomonas* sp. (11)	*Peridiniopsis* spp. (10–19)
X.2013	*Desmodesmus armatus* var. *longispina* (Chod.) E. Hegewald (13–25) *D. magnus* (Meyen) P.M. Tsarenko (10–11) *D. denticulatus* (Lagerh.) S.S. An, Fried et E. Hegewald (17) *Mougeotia elegantula* Wittr. (11) *Mougeotia* sp. (10–31) *Cladophora fracta* Kütz. (23) *Pseudopediastrum boryanum* (Turpin) E. Hegewald (15) *Coelastrum pseudomicroporum* Korsch. (44) *Ulnaria ulna* (17–24) *Nitzschia vermicularis* (Kütz.) Hantz. (26) *Nitzschia* sp. (10–38) *Staurosirella leptostauron* (Ehr.) D.M. Williams et Round (15–37) *Fragilaria capucina* (21) *Aphanocapsa holsatica* (13) *Planktolyngbya limnetica* (Lemm.) Kom.-Legn. et Cronb. (10–17) *Microcystis aeruginosa* (50) *Cryptomonas marssonii* (13)	*Staurosirella leptostauron* (15) *Nitzschia vermicularis* (14) *Cryptomonas marssonii* (16–45) *C. ovata* (32–34), *Euglena gracilis* Klebs (12) *Euglena* sp. (23) *Synura* cf. *uvella* (56)	*Nitzschia* sp. (10–20) *Navicula* sp. (10) *Cryptomonas marssonii* (30) *C. ovata* (20) *Planktolyngbya limnetica* (10)

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