The species composition and the taxonomic structure of phytoplankton in the lakes of Omsk region

O P Bazhenova, N N Barsukova, L V Korzhova, O O Krenz and O A Konovalova

Department of Ecology, Nature Management and Biology, Omsk State Agrarian University named after P.A. Stolypin, 1 Institutskaya sq., Omsk, 644008, Russian Federation

E-mail: op.bazhenova@omgau.org

Abstract. To assess the biodiversity of plankton algae from different types of Omsk lakes, phytoplankton studies were carried out in September 2020. The material was quantitative and qualitative phytoplankton samples taken from 38 lakes in Omsk region. The collection and processing of phytoplankton samples were carried out by the methods generally accepted in hydrobiology. The phytoplankton from Irtysh lakes is characterized by high species richness and complex structures. 382 species and intraspecific taxa (IWT) have been identified, including the nomenclature type of species from 8 divisions. 25 new algae from 6 divisions were identified in the study. The greatest species richness is characteristic of green algae (Chlorophyta); euglena algae (Euglenophyta) and cyanoprokaryotes (Cyanoprokaryota) also have a high diversity, which corresponds to the importance of these divisions in the taxonomic structure of phytoplankton in Omsk Irtysh region. The greatest diversity of phytoplankton was observed in old lakes; highly eutrophic shallow lakes in the south have a specific taxonomic structure. Low species richness of phytoplankton is characteristic of highly mineralized lakes.

1. Introduction
Numerous water bodies are under the intense influence of human activities. As a result, a significant amount of biogenic elements and organic matter gets into water bodies, which causes a number of negative consequences: depletion of water resources, water “blooming”, waterlogging, which deteriorates the water quality.

The bioindication methods are used to assess the quality of natural waters by the state of indicator species or communities of organisms, among which phytoplankton, being the primary link in the food chain in biotic communities, quickly reacts to the intake of biogenic and easily oxidized organic substances, participates in the formation of water quality and is the most sensitive indicator of the state of aquatic ecosystems.

The bioindication methods based on the species composition of phytoplankton assess results of all natural and anthropogenic processes occurring in the aquatic ecosystem. One of the most important structural indicators of phytoplankton communities is their species richness, that is, a biodiversity of algae.

When conducting research on biodiversity, it is necessary to have a taxonomic list of species. It helps to identify rare species of algae, which, when included in the regional Red Book, will contribute to the protection of water bodies. The most important natural potential of Omsk region is water
resources. All water bodies of the region belong to the Irtysh river basin; therefore, this territory is often called Omsk Priirtysh [1].

The biodiversity of algae in water bodies of Omsk Irtysh region is large. The first inventory of the algal flora was made in the 1960s [2]; many of the data are outdated due to significant changes in the state of water resources and the latest advances in algology. The results of long-term studies of phytoplankton carried out by the Department of Ecology, Nature Management and Biology of Omsk State Agrarian University have been published [3–6].

2. Methods and Equipment
The research was conducted by the Department of Ecology, Nature Management and Biology of Omsk State Agrarian University under contract No. 34-09 / 20 of 03.09.2020 with Omsk Scientific Center. The research object was samples of phytoplankton from different lakes in Omsk region taken in September 2020.

Sampling was carried out during the most intensive development of phytoplankton: late summer – early autumn. According to the previous study [6], it is in the summer-autumn period that the vegetation and biodiversity of phytoplankton in water bodies reach their maximum values.

When sampling phytoplankton, the depth of the water body, temperature and water transparency were measured using the Secchi disk. The chemical analysis of water was carried out at the accredited laboratory. In water samples, the following parameters were determined: pH, total ions (total mineralization), total hardness, hydrocarbonates, sulfates, chlorides, Ca2+, Mg2+, Na + K, ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, total phosphorus, BOD5, COD. The hydrochemical analysis of water bodies was carried out by the Alekin’s method [7].

Quantitative samples of phytoplankton with a volume of 0.5 l were taken by scooping from the surface (0–0.2 m) layer of water, and qualitative samples were taken simultaneously. The samples were fixed with 40% formalin until a faint odor appeared. After settling the samples in a dark place for 7–10 days, the samples were concentrated by the sedimentary method and processed by the conventional methods [8, 9] using the Euler Professor 770T light microscope. A total of 112 phytoplankton samples were processed.

Species were identified following domestic and foreign monographs and systematic summaries. New algae were identified by comparing the taxonomic list with the data provided in [6].

The taxonomic list of algae has been compiled taking into account modern systematic transformations. To check the relevance of the names, we used the Algaebase Internet resource database [10].

3. Results
The lakes are located in different physical and geographical zones (forest, forest-steppe and steppe) of Omsk region. They experience anthropogenic pressure. Lakes differ in size, degree of aquatic vegetation, hydrochemical indicators and other characteristics (Table 1).

The lakes are characterized by shallow water, the average depth does not exceed 2.0 m. The water bodies in the south (Azov, Cherlak, Kalachinsk, Okoneshnikovsk) are characterized by low water transparency (20-59 cm); in the lakes of Tar district located in the forest zone, water is more transparent (70-150 cm). The water temperature ranged from 10–19°C, which is favorable for the development of phytoplankton. The active reaction of the aquatic environment (pH) ranges from weakly alkaline to alkaline, which is also favorable for the development of phytoplankton. Mineralization of water and other hydrochemical parameters widely vary which determines the specificity of their phytoplanktocenoses (Table 1).
| Object                                      | Coordinates of sampling points | Average depth, m | Water transparency, cm | Water temperature, °C | Mineralization level | Class of water  | pH  |
|---------------------------------------------|--------------------------------|------------------|------------------------|-----------------------|---------------------|------------------|-----|
| Lake №1                                     | 54°47′11.13″ N 73°23′00.8″ E | 1.3              | 42                     | 15                    | salty.              | calcium chloride| 7.46|
| Lake №2                                     | 54°47′68.84″ N 73°23′39.42″ E | 2.0              | 50                     | 15                    | fresh               | calcium chloride| 6.64|
| Pond at the railway crossing                | 54°45′50.7″ N 73°22′43.3″ E | 1.0              | 45                     | 13                    | fresh               | chloride         | 6.58|
| Pond near Zvonarev Kut                      | 54°40′92.0″ N 73°24′05.6″ E | 1.4              | 40                     | 14                    | salty.              | hydrocarbons     | 7.52|
| Koshkol Lake                                | 54°35′50.6″ N 72°44′54.5″ E | 1.1              | 48                     | 16                    | salty.              | hydrocarbons     | 7.66|
| Lake №3                                     | 54°31′35.9″ N 74°25′86.0″ E | 1.1              | 48                     | 15                    | fresh               | hydrocarbons     | 6.78|
| Lake №4                                     | 54°29′74.5″ N 74°26′17.0″ E | 1.2              | 31                     | 12                    | fresh               | calcium chloride| 7.39|
| Karasor Lake                                | 54°22′98.1″ N 75°34′35.0″ E | 0.8              | 42                     | 14                    | salty.              | calcium chloride| 8.41|
| Lake №6                                     | 54°30′09.1″ N 74°23′71.6″ E | 1.0              | 45                     | 12                    | salty.              | hydrocarbons     | 7.33|
| Ulzhai Lake                                 | 54°14′38.1″ N 75°04′24.6″ E | 0.7              | 47                     | 16                    | salty.              | calcium chloride| 8.25|
| Terenkol Lake                               | 54°26′87.7″ N 75°36′03.8″ E | 0.9              | 35                     | 10                    | fresh               | hydrocarbons     | 6.82|
| Pond near Atmas                             | 54°03′60.9″ N 74°57′20.0″ E | 1.0              | 59                     | 15                    | fresh               | calcium chloride| 8.25|
| Ssylkino Lake                               | 54°30′32.1″ N 75°29′48.2″ E | 1.2              | 44                     | 16                    | salty.              | calcium chloride| 8.75|
| Zhartykol Lake                              | 54°22′25.1″ N 75°33′22.2″ E | 1.3              | 45                     | 15                    | salty.              | hydrocarbons     | 8.63|
| Porshnevo Lake                              | 54°24′11.2″ N 75°38′21.0″ E | 1.0              | 43                     | 17                    | salty.              | hydrocarbons     | 9.12|
| Lake №7                                     | 55°10′58.4″ N 74°56′90.0″ E | 0.9              | 48                     | 14                    | salty.              | chloride         | 7.64|
| Lake №8                                     | 55°10′70.9″ N 74°55′56.6″ E | 1.1              | 45                     | 11                    | fresh               | hydrocarbons     | 7.71|
| Lake №9 envoir of Krytye Luki village       | 55°09′17.7″ N 74°54′20.5″ E | 1.0              | 42                     | 10                    | fresh               | hydrocarbons     | 9.17|
| Kalach Lake                                 | 55°03′35.3″ N 74°36′15.1″ E | 0.6              | 20                     | 11                    | fresh               | hydrocarbons     | 6.72|
| Lake №10 envoir of Kulikovo                 | 55°03′51.7″ N 74°27′50.8″ E | 1.0              | 39                     | 16                    | fresh               | hydrocarbons     | 7.82|
| Lake №11 envoir of Sorochino                | 55°06′21.6″ N 74°46′24.1″ E | 0.9              | 42                     | 16                    | salty.              | hydrocarbons     | 9.15|
| Lake №12 envoir of Starodubka               | 55°04′27.9″ N 74°31′02.9″ E | 1.1              | 46                     | 15                    | fresh               | hydrocarbons     | 7.66|
| Lake Bolshe-Mitikino                        | 55°18′81.3″ N 74°40′04.5″ E | 1.5              | 45                     | 14                    | salty.              | chloride         | 7.05|

**Table 1.** Characteristics of the lakes in Omsk region, September 2020
| Lake Name          | Coordinates                     | Depth | Area (m²) | Type      | Salt Content               |
|-------------------|---------------------------------|-------|-----------|-----------|---------------------------|
| Lake Petrovo      | 56°57'01.1"N 74°09'78.3"E       | 1.4   | 130       | fresh     | hydrocarbonate            |
| Lake №13          | 56°48'74.4"N 74°36'09.6"E       | 1.4   | 100       | fresh     | hydrocarbonate            |
| Lake №14          | 56°56'56.1"N 74°21'97.3"E       | 1.7   | 150       | fresh     | hydrocarbonate            |
| Lake №15          | 56°41'11.2"N 74°31'51.7"E       | 1.0   | 70        | fresh     | hydrocarbonate            |
| Lake №16          | 56°40'23.2"N 74°30'24.6"E       | 1.7   | 150       | fresh     | hydrocarbonate            |
| Lake №17          | 54°45'56.2"N 75°29'54.6"E       | 1.4   | 49        | salty     | chloride                  |
| Lake №18          | 54°53'53.8"N 74°55'20.7"E       | 0.9   | 35        | salty     | chloride                  |
| Lake №19          | 54°57'01.8"N 74°58'77.1"E       | 1.0   | 35        | fresh     | hydrocarbonate            |
| Lake №20          | 54°49'09.0"N 75°11'05.4"E       | 1.2   | 35        | salty     | chloride                  |
| Lake №21          | 54°50'01.1"N 75°06'40.6"E       | 0.7   | 45        | salty     | chloride                  |

Okoneshnikovskoe

Lake Lebyazhye

Lake №17 (environs of Alekseevka)

Lake Travyanoe

Lake №18 (environs of Zolotaya Niva)

Lake №19 (environs of Nikolaevka)

Lake Gorkoye-1 (environs of the village Lenin)

Lake Gorkoye-2 (environs of Krestyki)

Lake Gorkoye-3 (environs of Okoneshnikovo)

Lake №20 (environs of Okoneshnikovo)
The trophic status of the lakes varies from the oligotrophic to hypertrophic one. Most lakes (17) are eutrophic, two lakes (No. 1, 4) are hypertrophic, five lakes are mesotrophic and 9 lakes are polytrophic. 7 water bodies are oligotrophic: lake Ulzhay and lake Svyazyno, where the development of phytoplankton is limited by high salinity of water; three lakes (No. 13-15) located in the forest zone are also oligotrophic. High salinity of water does not always limit the development of phytoplankton: for example, by the level of phytoplankton development, Porshnevo lake is polytrophic.

The taxonomic spectrum of phytoplankton is presented by 8 divisions, 16 classes, 35 orders, 65 families, 168 genera, 354 species and 382 varieties and forms, including the nomenclature type of the species (Table 2).

### Table 2. The taxonomic spectrum of phytoplankton in different types of lakes in Omsk region

| Division          | classes | order | family | genus | species | variety |
|-------------------|---------|-------|--------|-------|---------|---------|
| Cyanoprokaryota   | 1       | 5     | 16     | 29    | 57      | 58      |
| Cryptophyta       | 1       | 1     | 2      | 2     | 2       |         |
| Dinophyta         | 1       | 3     | 6      | 7     | 11      | 11      |
| Ochrophyta        | 3       | 3     | 4      | 8     | 25      | 26      |
| Euglenophyta      | 1       | 1     | 2      | 8     | 54      | 70      |
| Bacillariophyta   | 3       | 13    | 18     | 27    | 37      | 37      |
| Chlorophyta       | 4       | 6     | 13     | 82    | 153     | 162     |
| Charophyta        | 2       | 3     | 4      | 5     | 15      | 16      |
| **Total**         | **16**  | **35**| **65** | **168**| **354** | **382** |

The greatest species richness is characteristic of green algae (Chlorophyta); euglena algae (Euglenophyta) and cyanoprokaryotes (Cyanoprokaryota) are also distinguished by a high diversity.

Green algae occupy the first place in terms of species richness with a fairly large gap from representatives of other divisions at the genus level, which is generally typical of phytoplanktocenoses of most water bodies in the region.

Green algae are represented by four classes: Chlorophyceae, Ulvophyceae, Trebouxiophyceae, Chlorodendrophyceae. The main role in the formation of the species richness of green algae belongs to Sphaeropleales (98 IWT), in which species of the Scenedesmaceae family (52 IWT) occupy a significant place. High species richness is characteristic of Scenedesmus Meyen (16 IWT).

Among the green algae, nine taxa with a rank lower than the genus were identified, including Furcilla - 2 IWT (Lake No. 4, Lake Travyanoe), Pyramichlamys - 1 IWT (Lake Koshkol), Phacotus - 2 IWT (Lake No. 6), Scenedesmus - 2 IWT (pond at the railway crossing), Tetrastrum - 1 IWT (lake No. 8), Scherffelia - 1 IWT (lake No. 6).

Euglena algae rank second in terms of species richness; they are represented by two classes and eight genera. The most important are Euglena Ehrenberg (18 IWT) and Trachelomonas Ehrenberg (23 IWT). The high species richness of euglena algae indicates [11] the eutrophication and pollution of water bodies with easily oxidized organic substances.

10 new representatives of euglena algae with a rank lower than the genus were identified, including Euglena - 3 IWT (Lake No. 1), Strombomonas - 1 IWT (Lake No. 19), Trachelomonas - 2 IWT (Lake Terenkol), Lepocinclis - 1 IWT (Lake Terenkol), and Pacus - 3 IWT (Lake Terenkol, Lake No. 8, Lake Travyanoe).

Cyanoprokaryotes rank third in terms of species richness. They include five orders: Synechococcales (40 IWT), Spirulinales (2 IWT), Oscillatoriales (5 IWT), Nostocales (10 IWT) and
Pleurocapsales (1 IWT). The highest species richness is typical of Aphanocapsa (7 IWT) and Dolichospermum (7 IWT).

The phytoplankton contains potentially toxic species of cyanoprokaryotes (Dolichospermum flos-aquae (Brébisson ex Bornet et Flahault) Wacklin, Hoffmann et Komárek, Microcystis aeruginosa (Kützing) Kützing, Aphanozomenon flos-aquae Ralfs ex Bornet et Flahault, Coelosphaerium kuetzingianum Nägeli), which, when the vegetation level rises to the water blooming ater, can become sources of toxins and cause adverse health effects [12].

An increase in the level of vegetation before the "bloom" of water can become sources of toxins and cause adverse health effects of the population and domestic animals [12].

Among the cyanoprokaryotes, two new species were found: Merismopedia marssonii Lemmermann (Lake No. 4), Cyanarcus hamiformis Pascher (Lake Travyanoe).

Diatoms are represented by Coscinodiscaceae (8 IWT) Fragilariophyceae (9 IWT) and Bacillariophyceae (20 IWT). The composition of pennate diatoms is dominated by random planktonic species, the share of truly planktonic species is insignificant.

Among the representatives of the Coscinodiscaceae class, Stephanodiscus hantzschii Grunow is a common species.

One new species, Amphiprora Ehrenberg sp. (Lake Travyanoe), was found in the composition of diatoms.

The importance of other divisions of algae in the taxonomic composition of phytoplankton is insignificant, but among these divisions 3 IWT are new species for the Omsk Priirtysh region - Charophyta - 1 IWT - Cosmarium humile var. humile (Gay) Nordstedt (Lake No. 6), division Ochrophyta - 2 IWTs - Pseudostaurastrum hastatum (Reinsch) Chodat (Lake Petrovo) and Dinobryon suecicum var. longispinum Lemmermann (Lake Terenkol).

4. Conclusion

Thus, the taxonomic composition of phytoplankton in the Omsk Irtysh lakes is characterized by high species richness and complex structures. To date, 382 species and intraspecific taxa have been identified, including species from 8 divisions: Cyanoprokaryota - 58, Cryptophyta - 2, Dinophyta - 11, Ochrophyta - 26, Euglenophyta - 70, Bacillariophyta - 37, Chlorophyta - 162, Charophyta - 16.

The greatest species richness is characteristic of green algae (Chlorophyta); euglena algae (Euglenophyta) and cyanoprokaryotes (Cyanoprokaryota) are also distinguished by a high diversity, which, in general, corresponds to the importance of these divisions in the taxonomic structure of phytoplankton of Omsk Irtysh region [6].

The species richness of lacustrine phytoplankton is high, the greatest biodiversity was observed in the oxbow lakes (Petrovo, Kalach). High biodiversity and specific taxonomic structure was observed in eutrophic shallow lakes in the south of the region. These lakes are sources of phytoplankton biodiversity, which is carried by waterfowl that live in mass on these lakes. Low species richness of phytoplankton is characteristic of highly mineralized lakes (Ulzhai, Gorkoye, Linksino, etc.).

25 species and intraspecific taxa of algae from 6 divisions which are new for the region were identified: Cyanoprokaryota - 2, Ochrophyta - 2, Euglenophyta - 10, Bacillariophyta - 1, Chlorophyta - 9, Charophyta - 1.

The studies made it possible to expand the taxonomic list of phytoplankton in Omsk Irtysh region and to perform additional works on the identification of rare species of algae.

References

[1] Rusakov V N 2006 The Land We Live On. Nature and nature management of the Omsk Irtysh region (Omsk: Publishing house Manifesto)

[2] Andreev G P, Goryacheva G I, Skabichevsky A P, Chernyavskaya M A, Chistyakov L D 1963 Algae of the Irtysh River and its Basin Proceedings of Tomsk state University 152 69-103
[3] Bazhenova O P, Barsukova N N, German L V, Igoshkina I Yu, Konovalova O A, Mamayeva O O 2012 Chryophyta of Water Bodies of Omsk Priirtyshye (Russia) International Journal on Algae 14(4) 315–322.
[4] Bazhenova O P, Krenc O O, Korzhova L V, Barsukova N N, Konovalova O A 2014 Cyanoprokaryota in Plankton of the Rivers and Lakes of Omsk Priirtyshye (Russia) International Journal on Algae 16(2) 144–155.
[5] Bazhenova O P 2017 Phytoplankton and Ecological Status of Forest Lakes in the Omsk Priirtyshye Contemporary Problems of Ecology 10(3) 240–249.
[6] Bazhenova O P 2019 Phytoplankton of the Omsk Irtysh region (Omsk).
[7] Alekin O A 1952 Hydrochemistry (Leningrad: Gidrometeoizdat).
[8] Abakumov V A 1977 Water quality control by hydrobiological indicators in the system of the USSR hydrometeorological service, in: Scientific bases of surface water quality control by hydrobiological indicators (Leningrad) pp 93–100.
[9] Fedorov V D 1979 On the methods of studying phytoplankton and its activity (Moscow: Moscow University).
[10] Guiry M D, Guiry G M 2020 AlgaeBase. World-wide electronic publication (National University of Ireland, Galway) Retrieved from: http://www.algaebase.org (Date of access: 20.10.2020).
[11] Safonova T A 1987 Euglena algae of Western Siberia (Novosibirsk: Nauka, Siberian branch).
[12] Kondratyeva N V, Kovalenko O V 1975 Brief guide to the species of toxic blue-green algae (Kiev: Naukova Dumka).