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Taxonomic Analysis and Ecological Features of the Algal Flora of the Water Bodies of the West Zarafshan Range

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Abstract

There are a number of reservoirs in the West Zarafshan Range, which have their own water-saturated, hydrographic, soil and ecological features. In this regard, their algoflora is also formed in its own way. As a result of research in this area, 217 species of algae were identified, belonging to 5 divisions, 11 classes, 37 orders, 57 families and 97 genera. The development and distribution of organisms in water is influenced by a number of external factors, such as: temperature, light, mineral and organic substances, active-reactive water environment, gas regime (oxygen, carbon dioxide, hydrogen sulfide), flow rate, change in water volume, degree transparency and wave formation.

Keywords

Western Zarafshan, Reservoirs, Algal Flora, Taxa, Eurytherms, Stenotherms, Polymorphs

1. Introduction

The Zarafshan Mountains are part of the Pamir-Alai Range, and the western part is located on the territory of the Urgut and Nurabad regions of the Samarkand region. The height of these mountains at the highest peak is 2150 m above sea level (Chakilkalon) (Figure 1). In these areas, there are different types of reservoirs, fed mainly by snow, rain and spring water. A comprehensive ecological analysis of the composition of algoflora increases the possibilities of understanding the hydrobiological and hydroecological processes occurring in it, as well as the management of biological resources. The unique ecological conditions of the reservoirs of the West Zarafshan mountain range ensured the formation of a

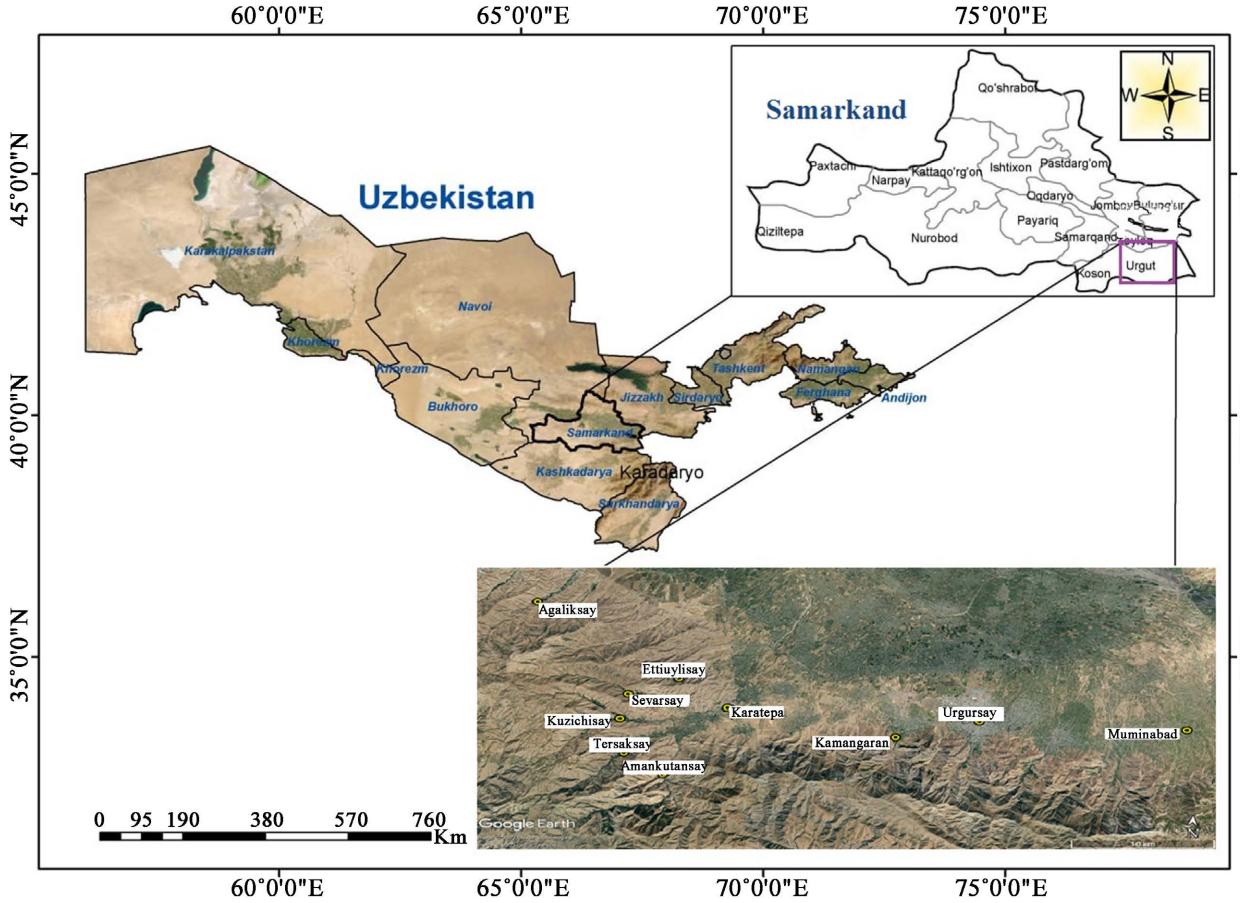

Figure 1. Reservoirs of the West Zarafshan Range.

peculiar algoflora. According to the analysis, eurythermal species were clearly in the lead. Plankton-benthic species are found in the composition of the algoflora of all water bodies. A separate study of the influence of environmental factors on water bodies in natural conditions causes some difficulties.

In the West Zarafshan ridge, there are different reservoirs which are trying different sources. The studied reservoirs are mainly from mountain rivers, atmospheric precipitation (snow, rain) and anthropogenic sources. Mountain rivers are mainly trying from atmospheric precipitation and anthropogenic sources. Therefore, their ecological characteristics are different. The study of the algoflora of this region in connection with environmental factors is of great scientific and practical importance.

A few studies of the algal flora of this region do not make it possible to compile a complete taxonomic composition of the algae and their ecological features.

Therefore, we studied large reservoirs of this region and analyzed the formation of algoflora in relation to water temperature.

An analysis of the literature shows that if in the past the water bodies of the studied region—Amankutansay, Agaliksay, Urgutsay and Ettiuylisay were studied only from a floristic point of view, then a comparative analytical, as well as taxonomic analysis was not carried out. In addition, the ecological features of the

algoflora have not been studied. Y.Sh. Tashpulatov *et al.* [1] [2] [3] [4] carried out an ecological analysis of the algal flora of the middle reaches of the Zarafshan River and some water bodies.

A number of authors have studied the taxonomic composition and ecological features of the algoflora of different reservoirs in Central Asia and adjacent territories [5] [6] [7] [8].

2. Methods Studied

When collecting, fixing, labeling and preserving algological samples, methods for collecting and studying freshwater algae were used. Over 190 algae samples were collected during the research period. 105 of them are plankton, 45 are benthos, 40 are periphyton. Phytoplankton samples were collected by the settling method (1 liter of water was taken with subsequent settling) or simply scooping up water (with intensive development of algae). Fouling samples were taken together with the substrate or scraped off the top layer from objects immersed in water. Phytobenthos were sampled using a siphon, scraper or spoon (with a sharpened side side). At the points of collection of algological samples, the temperature of the water and the active reaction (pH - litmus strips) of the water were determined. Most samples were fixed in 4% formalin, and some of them were examined in vivo. The samples were transported to the laboratory, where they were examined under MBI-3 and Carl Zeiss Jena microscopes with AxioCam MRc-5 high-resolution color digital cameras and AxioVision 4.8 software at a magnification of 40 × 16 and 100 × 16. To identify the species of diatoms, the technical processing of the samples was carried out according to the generally accepted method for studying diatoms. To determine the species composition, a Carl Zeiss microscope was used. When determining the species composition of algae, the determinants [9] [10] [11] [12] [13] and published monographs [14] [15] [16] were used; modern identification of taxa was carried out using international database http://algaebase.org [17].

3. Results and Discussion

Algoflora of 3 reservoirs (Karatepa, Kamangaron, Muminabad) and 7 mountain rivers (Amankutansai, Tersaksai, Kuzichisai, Ettiuylisai, Sevarsai, Agalyksai, Urgutsai) were studied in the studied territories. The algoflora of reservoirs and mountain sai differs significantly in taxonomic relations. The water temperature of the studied reservoirs fluctuates on average per annum from +2˚C to +28˚C. The transparency of the water is about 0.50 - 0.79 m., pH 5.8-6.3. The total mineralization of the water is 0.455 - 0.780 mg/l. The water temperature of the studied mountain river ranges from +4˚C to +23˚C The transparency of the water is about 0.20 - 0.33 m, the total mineralization of the water is 0.210 - 0.570 mg/l. water flow rate 1.5 - 2.2 m/s, pH 6.7 - 7.4. In warm seasons (late spring, summer and early autumn) there is a sharp warming of the waters of reservoirs up to 32˚C (**Figure 2**).

Ecological characteristics of the remaining 7 mountain rivers are very close to each other (Figure 3).

These phenomena are not observed in mountain streams due to constant currents. All these factors affect the differences in the composition of algoflora between reservoirs and flowing mountain streams.

The algal flora of the water bodies of the West Zarafshan Range is being thoroughly studied for the first time. There are few given algoflora by some researchers [3] [4] [18]. They give information only from a floristic point of view. The taxonomic composition, analysis of algoflora and the influence of water temperature on the formation of algoflora are analyzed for the first time.

Among the reservoirs of the study area, the Karatepa, Kamangaran and Muminabad reservoirs are fed mainly by streams flowing into them, and Amankutansay, Kuzichisay, Sevarsay, Agaaliksay, Ettiuylisay and Urgutsay are fed by

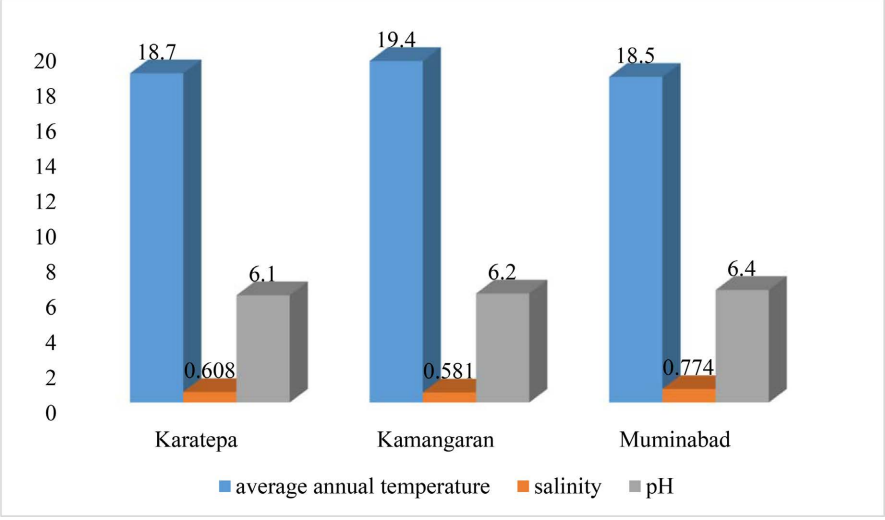

Figure 2. Ecological indicators of the reservoirs of the West Zarafshan Range.

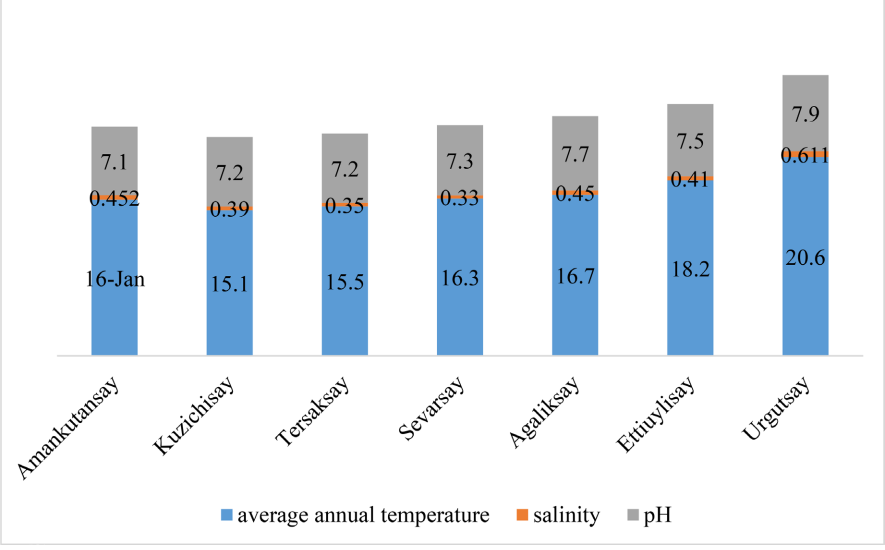

Figure 3. Ecological indicators of a mountain river of the West Zarafshan Range.

snow and rain water during the rainy period, and in the rest of the year by streams. The algal flora of water bodies in the area of algological research is unevenly distributed (Table 1). In the course of research, 219 species of algae belonging to 5 divisions (Cyanoprocaryota, Bacillariophyta, Euglenophyta, Chlorophyta, Charophyta), 11 classes, 37 orders, 57 families, 98 genera (Table 1) were identified from the studied reservoirs. As can be seen from the data in the table, a significant part of the algae found in the studied water bodies were diatoms. They are represented by 132 species and make up 60.27% of the total algoflora. The next places were occupied by cyanophytes 39 species (17.80%), green algae 18 species (8.21%), chara 18 species (8.21%) and euglena 4 species (1.82).

The studied reservoirs ensured a relatively diverse formation of algoflora in it, depending on the diversity of its characteristics and location. In the course of our analysis, we focused mainly on the analysis of genera and families, which should reveal the mutual similarities and differences of the flora in different water bodies, as well as explain the features of their formation. In total, 57 families are registered in the algoflora. Among them, the number of leading polymorphic families, uniting 4 or more species, was 19, which is 33.33% of the total number of families. Of these leading families, 2 families (Microcystaceae, Oscillatoriaceae) belong to cyanophytes, 11 to diatoms (Stephanodiscaceae, Fragilariaceae, Cymbellaceae, Gomphonemataceae, Cocconeidaceae, Amphipleuraceae, Pinnulariaceae, Naviculaceae, Bacillariaceae, Rhopalodiaceae, Surirellaceae), 1 to euglena (Euglenadaceae). 2 for green algae (Scenedesmaceae, Oedogoniaceae) and 3 for charophytes (Desmidiaceae, Closteriaceae, Zygnemataceae). These polymorphic families united 150 species belonging to 52 genera in the algal flora, which accounted for 53.06% of the total number of genera, as well as 69.12% of the total number of species (Table 2).

The number of polymorphic genera dominating in terms of the number of species in the composition of the algoflora was 27. They include 133 species, which is 61.29% of the algoflora (Table 3). Among the genera, genera containing more than 4 species are *Oscillatoria* - 12, *Nitzschia* - 10, *Fragilaria* - 9, *Navicula* - 9, *Cymbella* - 8, *Gomphonema* - 6, *Phormidium* - 6, *Spirogira* - 6, *Cosmarium* - 5, *Ulnaria*, *Cocconeis*, *Epithemia*, *Gloeocapsa*, *Scenedesmus*, *Oedogonium*,

Table 1. Taxonomic composition of algoflora.

№	Division	class	Order	Family	Genus	Species	%
1	Cyanoprocaryota	2	5	11	15	39	17.97
2	Bacillariophyta	2	17	25	58	130	59.91
3	Euglenophyta	1	1	1	1	4	1.85
4	Chlorophyta	4	11	15	17	26	11.98
5	Charophyta	2	3	5	6	18	8.29
	Total:	**11**	**37**	**57**	**97**	**217**	**100**

Table 2. The spectrum of polymorphic families in the composition of the algoflora.

Place in flora	Families	Number of species/%	Place in flora	Families	Number of species/%
1	Fragilariaceae	24/11.05	11 - 12	Microcystidaceae	4/1.84
2	Oscillatoriaceae	20/9.21	11 - 12	Stephanodiscaceae	4/1.84
3	Bacillariaceae	16/7.37	11 - 12	Pinnulariaceae	4/1.84
4	Cymbellaceae	15/6.91	11 - 12	Euglenadaceae	4/1.84
5	Naviculaceae	10/4.60	11 - 12	Scenedesmaceae	4/1.84
6 - 7	Gomphonemataceae	7/3.22	11 - 12	Oedogoniaceae	4/1.84
6 - 7	Cocconeidaceae	7/3.22	11 - 12	Desmediaceae	4/1.84
8	Spirogyraceae	6/2.76	11 - 12	Closteriaceae	4/1.84
9 - 10	Amphipleuraceae	5/2.30	11 - 12	Surirellaceae	4/1.84
9 - 10	Rhopalodiaceae	5/2.30	**Total:**	**19**	**150/69.1**

Note: place in flora - by the number of species, % - in the total number of species in algoflora.

Table 3. The spectrum of polymorphic genera in the algoflora.

Place in flora	Genus	Number of species/%	Place in flora	Genus	Number of species/%
1	*Oscillatoria*	12/5.52	9 - 10	*Oedogonium*	4/1.84
2	*Nitzschia*	10/4.60	9 - 10	*Closterium*	4/1.84
3 - 4	*Fragilaria*	9/4.14	9 - 10	*Euglena*	4/1.84
3 - 4	*Navicula*	9/4.14	11 - 12	*Aulocoseira*	3/1.38
5	*Cymbella*	8/3.68	11 - 12	*Diatoma*	3/1.38
6 - 7	*Gomphonema*	6/2.76	11 - 12	*Eunotia*	3/1.38
6 - 7	*Phormidium*	6/2.76	11 - 12	*Halamphora*	3/1.38
6 - 7	*Spirogira*	6/2.76	11 - 12	*Diploneis*	3/1.38
8	*Cosmarium*	5/2.30	11 - 12	*Amphora*	3/1.38
9 - 10	*Ulnaria*	4/1.84	11 - 12	*Surirella*	3/1.38
9 - 10	*Cocconeis*	4/1.84	11 - 12	*Merismopedia*	3/1.38
9 - 10	*Epithemia*	4/1.84	11 - 12	*Microcystis*	3/1.38
9 - 10	*Gloeocapsa*	4/1.84	11 - 12	*Ulothrix*	3/1.38
9 - 10	*Scenedesmus*	4/1.84	**Bcero:**	**27**	**133/61.29**

Note: place in flora—by the number of species, %—in the total number of species in algoflora.

Closterium, and other genera such as *Aulocoseira*, *Diatoma*, *Eunotia*, *Halamphora*, *Diploneis*, *Amphora*, *Surirella*, *Merismopedia*, *Microcystis*, *Ulothrix* contained 3 species each. The remaining 70 families in the composition of the

algoflora unite 84 species. An analysis of the leading families in terms of the number of species in the algoflora of the water bodies of the studied regions showed that the first 5 families out of 19 polymorphic families turned out to be diatoms and cyanoprocaryotes. The abundance of minerals in the water bodies of Central Asia ensures the rapid development of many diatoms, which in turn ensures the clear leadership of this group of algae. Similar information can be seen in the works of algologists who studied the flora of other reservoirs of Central Asia.

Temperature—is one of the main factors that ensure the spread and development of algae. Among the studied reservoirs, the temperature regime of water in the Karatepa, Kamongaron and Muminabad reservoirs differs sharply from the streams. Since the exchange of water in reservoirs is slower than in streams, in addition, the temperature in reservoirs is characterized by sharp drops during the day. In the study area, relatively fast water flow was found in Amankutansay, Kuzichisay, Sevarsay, Tersaksay, Ettiuylisay, Agalyksay and Urgutsay, which provides a relatively stable temperature.

The water temperature in the Karatepa, Kamangaran and Muminabad reservoirs, where studies were carried out, ranges from +11˚C + 15˚C (April) to +20˚C + 24˚C (May). In early spring, diatoms are mainly found in reservoirs. It has been established that species such as *Stephanocyclus meneghinianus*, *Aulacoseira ambigua*, *Diatoma elongata*, *Fragilaria recapitellata* are common in water bodies. As the temperature rises, cyanoprocaryotes, green algae and euglena begin to develop. During the summer months, such species as *Microcystis aeruginosa f. flos-aquae*, *Gloeocapsa minuta*, *Spirogyra pratensis Mougeotia aspera*, *Cosmarium laeve*. Closer to the autumn months, the water temperature in reservoirs is +12˚C + 14˚C. At this time, the number of euglena and cyanoprocaryotes is significantly reduced. By the end of autumn, diatoms again begin to take the lead in the composition of the algoflora.

The water temperature of the studied streams does not actually differ from each other. Since they are geographically located close to each other, their sources of saturation are similar, and the soil features are also the same. In the spring months, it was noticed that the water temperature of the streams ranges from +10˚C + 12˚C to +15˚C + 18˚C. At this time, diatoms are found in large numbers, and such species as *Tabularia tabulata*, *Ulnaria acus*, *Synedra goulardii*, *Cymbella parva* have been found to be widespread. By the end of spring, *Chara foetida*, *Spirogyra punctata*, *Ulothrix aequalis* were observed in the upper streams.

In summer the water temperature rises to +15˚C + 18˚C. At that time, periphyton and benthic species predominated in the waters of streams. For example, species such as *Ulothrix tenerrima*, *Cladophora glomerata*, *Characium strictum Gomphonema intricatum*, *Cocconeis pediculus*, *Neidium bisulcatum*, *Navicula radiosa*, *Oscillatoria formosa*, *Calothrix aeruginosa*.

By mid-autumn, there is a significant decrease in water in streams. The algae flora is also significantly reduced. At the end of autumn, the water in some small streams dries up altogether.

In 2021-2022, in the middle of summer, it was noticed that the water in Urgutsay almost dried up after leaving the city of Urgut. According to the results of the analysis in the studied reservoirs, there were 72 (33.17%) stenothermic species, 145 (66.82%) eurythermal species (Figure 4).

Analysis of the data obtained showed that eurythermal species accounted for 3/2 of the total number of species in the studied reservoirs. This situation was observed in all departments. Stenothermic species are found only in one or two seasons, while eurythermal species are found in water bodies in all seasons of the year. It has been established that eurythermal species are found in large numbers among diatoms and prevailed by a large margin compared to stenothermic ones. This situation was also reflected in the works of other researchers who conducted algophological studies in mountainous regions.

Stenothermic species include such species as: *Cyanothrix gardneri*, *Merismopedia glauca*, *Microcystis aeruginosa*, *Oscillatoria irrigua*, *Stephanocyclus meneghinianus*, *Fragilaria montana*, *Fragilaria rumpens*, *Cymbella hustedtii*, *Pseudosphaerocystis lacustris*, *Scenedesmus acuminatus*, *Merismopedia punctata*, *Oscillatoria nigra*, *Phormidium ambiguum*, *Melosira varians*, *Aulacoseira ambigua*, *Odontidium anceps*, *Synedra goulardii*, all species of the genus *Euglena*, *Characium strictum*, *Scenedesmus quadricauda*, *Ulothrix zonata* are eurythermal species.

4. Conclusions

An analysis of the genera leading in terms of the number of species in the composition of the algoflora of the studied reservoirs shows that 12 species (5.52%) belonging to the genus Oscillatoria are the clear leader. Of the studied objects, in 3 reservoirs, that is, in the Karatepa, Kamangaran and Muminabad reservoirs, with a weak current and low exchange, the waters of which are collected and

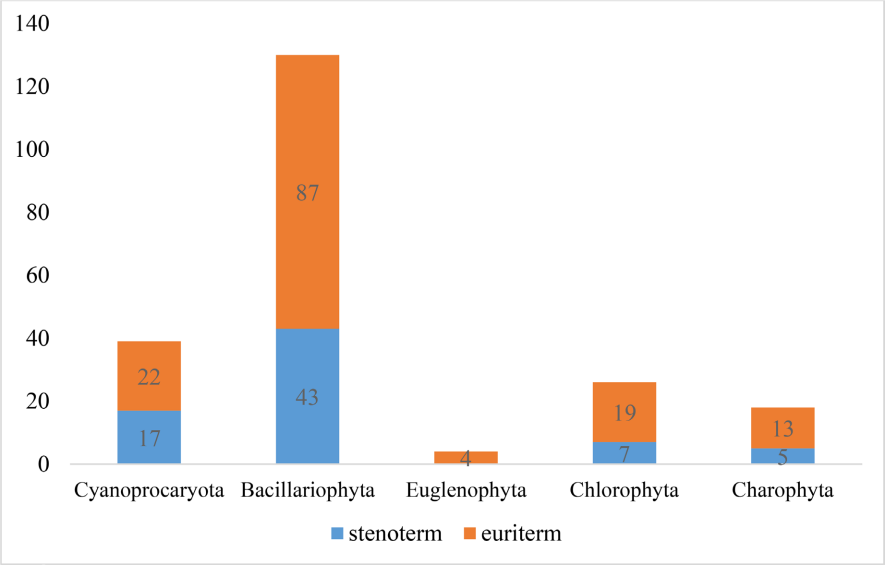

Figure 4. Species composition of algoflora depending on temperature.

saturated mainly due to streams flowing from settlements, as well as the temperature on the water surface, create favorable conditions for the development of cyanophyte algae, as a result of which the wider distribution of planktonic forms of algae can be explained.

The fact that diatoms again lead in the next 2 - 6 places, in terms of the number of species, is due to the fact that, as noted above, they are found in all water bodies of Central Asia. Due to the fact that the studied reservoirs are mainly located in mountainous and foothill areas, the temperature in them does not change sharply during the seasons, and the daily temperature amplitude also does not differ sharply, as a result of the rapid flow of water in mountain streams, as well as the uniformity of temperature in different places of reservoirs provided a clear leadership of eurythermal species. In the reservoir, stenothermic species are more common, which is explained by different temperatures in different layers of water.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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