Planktonic ciliates communities of hydrological natural monuments of the Southern Urals, the Lake Kandrykul and the Lake Aslykul, Russia

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Abstract. A comparative analysis of communities of plankton ciliates has been performed for two large clear-water, slightly alkaline lakes belonging to the hydrological natural monuments of the Southern Urals (Russia). The fauna of ciliates was typical for most oligo-mesotrophic reservoirs. However, in addition to tintinnids and strombidids, small species of the genera Balantion, Urotricha, and Askenasia had higher abundance in the Lake Kandrykul, and large colonial Epicarchesium pectinatum, in the Lake Aslykul. In general, the ciliates abundance in the lakes did not exceed 789 Cells L⁻¹ and 8,978 Cells L⁻¹, the biomass, 45 mg m⁻³ and 70 mg m⁻³, respectively. The Lake Aslykul had higher water mineralization, a greater presence of mineral suspension, and a smaller area overgrown by higher aquatic vegetation; it was characterized by poor species composition, low taxonomic and structural diversity, and lower abundance and biomass of ciliates. The heterogeneity of the lake structural characteristics was less expressed in the Lake Kandrykul, due to the underwater associations of submerged aquatic plants, which smoothed the differences between ciliates communities in different ecotopes. The mixotrophic ciliates in both lakes contributed 20-25% of total abundance and 13-44% of total biomass. The degree of organic pollution corresponded to the β-mesosaprobic in both lakes as followed by saprobity indicator species.

1. Introduction
The establishing and managing the specially protected natural areas (SPNAs) serve as a guarantee for the preservation of landscape and its biological diversity [1]. The Republic of Bashkortostan, located at the crossroads of Europe and Asia, has a unique diversity of the natural complexes; its biological resources are considered as a source of biodiversity for the entire European region. The republic has a well-developed network of protected areas, including currently 225 SPNAs of different categories [1]. The largest lakes in the Southern Urals, Aslykul and Kandrykul, are known the best among more than 3,000 lakes of various origins in the western part of Bashkortostan. Both lakes are hydrological natural monuments of regional significance and are located on the territory of natural parks of the same names. Both lakes have great esthetic, recreational, and environmental significance and, like any "natural laboratory", provide a rich material for scientific studies, in particular, for the biodiversity conservation. Despite their geographical proximity (there is less that 100-km distance between them), a common ancient valley and similar origin, the mineralization of waters of these lakes differs almost twofold due to various bedrocks. Planktonic organisms are very sensitive to this variation. Protozoa, in particular, ciliates (Ciliophora), are important and often unjustly overlooked component due to their
small size; they are usually not considered as a "classic" and indispensable object for ecosystems monitoring.

The study aims to compare the species richness, species diversity, and quantitative characteristics of communities of plankton ciliates of the lakes Kandrykul and Aslykul.

2. Materials, methods and research area

2.1. Methods of sampling and material processing

The study of free-living planktonic ciliates of two lakes was carried out at the same time periods (June and August-September 2010; May, July, and September 2012). The samples from the open-water part of the lakes were taken along three transects in the Lake Kandrykul, and at the deep-water station in the Lake Aslykul (figure 1). Samples were taken with a Ruttner bottle every meter from the surface to the bottom in the pelagic zone, and only from the surface in the open (macrophyte-free) littoral zone and in macrophyte associations. A comparative analysis of the spatial distribution of ciliates in the lake was performed for the samples obtained from the water surface only. The quantitative analysis was carried out for the samples of 500-1,000-mL volume (depending on the ciliates abundance); the water was pre-concentrated down to a 10-mL volume by gravity (no-vacuum) filtration of water through a membrane filter (pore diameter of 4-10 μm), then fixed with a saturated solution of mercury (II) chloride. Cell counts were performed at glycerol slides [2]. Identification of the ciliate species was performed both in live sample and using standard protozoological and histochemical methods [3-5]. The taxonomy is given according to the taxonomic system suggested by E Small and D Lynn [6, 7]. The size structure was assessed using a method originally developed for bacterioplankton [8]. Attribution to the size class was based on the principle of doubling the cell volume. In order to assess species diversity, Shannon index and Pielou index were calculated. The degree of impact of certain factors on the ecosystem was assessed by the openness index, i.e. the ratio of the lake area to its average depth [9].

![Diagram of Lake Kandrykul and Lake Aslykul](image)

**Figure 1.** Scheme of the study area and location of sampling stations. Dark gray color indicates the zone with the highest degree of the aquatic vegetation overgrowth.

2.2. The study area and abiotic conditions for hydrobionts

The lakes Aslykul (54°18'46" N; 54°34'38" E) and Kandrykul (54°30'10" N; 54°03'50" E) are the largest water bodies in the Pre-Urals (table 1); they are located at the northeastern margin of the Bugulma-Belebeyevskaya upland in the river valleys. The Lake Kandrykul belongs to the Ik River basin, the Lake Aslykul belongs to the Dema River basin (a tributary of the Agidel River). They are quite similar by their morphometry (table 1). According to the literature, their origin is karst, palaeo-erosive [10, 11].
Ion composition of water of the both lakes is sodium-magnesium bicarbonate-sulfate, type II, M 1.2–1.9 g L\(^{-1}\), pH 8.5–8.98 [11]. The mineralization in the Lake Aslykul is 1.9 times higher comparing to that in the Lake Kandrykul, the content of chloride ions is higher both in absolute (2.6 times, mg L\(^{-1}\)) and relative (1.6 times, %) values [11]. According to the degree of mineralization, the water of the Lake Aslykul is considered as brackish, of the Lake Kandrykul, in between fresh and brackish waters [12]. However, there is a tendency to decrease the water mineralization of the Lake Kandrykul; on average, it was 984 mg L\(^{-1}\) during the study period in 2010 and 2012 [13]. The water in both lakes is slightly alkaline. Water transparency varied from 3 to 7 m in the Lake Kandrykul and from 1.3 to 3.6 m in the Lake Aslykul. Both lakes belong to clear-water type (water color <20 °Pt) and are characterized by a high content of mineral suspension, especially the Lake Aslykul, where suspension also contributes to the blue color of its waters. Macrophytes play an important role in the ecosystem of the Lake Kandrykul [13]. In 2010, this lake was characterized by the development of dense thickets of submerged aquatic plants down to the depths exceeding 5 m (Hippuris vulgaris L., Chara sp., Ranunculus circinatus Sibth., etc.), in addition to coastal macrophytes. The area of macrophytes overgrowth in the Lake Aslykul is visually much smaller and comprises mainly coastal water vegetation (reeds and cattails). Temperature regime of both lakes was characterized by episodic summer thermal stratification, accompanied by with a pronounced thermocline at 7-11-m depth in the deeper Lake Kandrykul and by homothermy in the Lake Aslykul, except June 2010, when a subsurface thermocline was recorded. The entire water column in both lakes is aerobic, which is favorable for hydrobionts. The trophic state of the Lake Kandrykul was assessed as mesotrophic for [13], of the Lake Aslykul, as oligotrophic and transitional to mesotrophic [10, 14].

3. Results

3.1. Taxonomic structure of ciliates communities

In total, 130 species of ciliates in the Lake Kandrykul and only 34 species in the Lake Aslykul were identified during the study period (table 2, figure 2). The similarity of ciliate fauna of the lakes was low (32% according to the Sørensen coefficient). Classes Oligohymenophorea, Litostomatea, Spirotrichea, and Prostomatea dominated by the number of species. However, the representatives of the class Oligohymenophorea dominated in the taxonomic structure of the Lake Kandrykul, while the species of the class Spirotrichea, in the Lake Aslykul. The absence of representatives of different classes and small number of species per genus indicate a poor taxonomic diversity of the ciliate community in the Lake Aslykul.

| Lake     | Class | Sub-class | Order | Family | Genus | Species |
|----------|-------|-----------|-------|--------|-------|---------|
| Kandrykul| 10    | 11        | 27    | 55     | 79    | 130     |
| Aslykul  | 4     | 7         | 13    | 19     | 28    | 34      |

Table 1. Morphometric characteristics of the studied lakes [1, 11].

| Lake     | Lake volume (10\(^6\) m\(^3\)) | Lake area (km\(^2\)) | Drainage area (km\(^2\)) | Length (km) | Width (km) | Depth (m) average | Depth (m) max. | Openness index |
|----------|---------------------------------|----------------------|---------------------------|-------------|------------|------------------|----------------|---------------|
| Kandrykul| 112.7                           | 15.6                 | 67.1                       | 6.55        | 2.38       | 7.2              | 15.6           | 2.16          |
| Aslykul  | 119                             | 23.5                 | 106.0                      | 7.1         | 3.31       | 5.1              | 8.1            | 4.61          |

Table 2. Taxonomic structure of ciliates in the lakes Aslykul and Kandrykul.
3.2. Species richness and species diversity

The community of ciliates in the Lake Aslykul is characterized by a poor species composition in general, by a small number of species per sample (2-12), low species diversity (Shannon index by abundance $H_n = 0.59-2.89$, by biomass, $H_b = 0.10-2.73$), and low alignment (Pielou index by abundance $E_n = 0.72$, by biomass, $E_b = 0.57$) in comparison with that of the Lake Kandrykul (table 3). The largest number of species (12) and the highest index of species diversity ($H_n = 2.89$) were recorded in the open water zone near the reed beds in the Lake Aslykul. In the Lake Kandrykul, maximum species richness was recorded in reed (41 species of ciliates), and maximum species diversity, in the plankton communities around the chara algae beds and reed beds ($H_n = 3.76$ and $H_b = 4.13$).

Table 3. Average (maximum) values of the species diversity and quantitative characteristics of ciliates communities in different ecotopes of the studied lakes in 2010 and 2012.

| Ecotope            | Number of species | Shannon index | Abundance (cells L$^{-1}$) | Biomass (mg m$^{-3}$) | Average cell mass (µg) |
|--------------------|-------------------|---------------|-----------------------------|-----------------------|------------------------|
|                    | per sample        | total         | per sample                  | total                 |                        |
| Lake Aslykul       |                   |               |                             |                       |                        |
| pelagial, 0m-bottom| 6.2(11)           | 27            | 1.73(2.66)                  | 2.40                  | 128(789)              | 4.2(33.3)             | 0.033                |
| pelagial, 0 m      | 6.0(11)           | 15            | 1.43(2.14)                  | 1.91                  | 308(789)              | 10.0(33.3)            | 0.032                |
| open littoral      | 4.7(12)           | 16            | 1.35(2.89)                  | 2.66                  | 51(64)                | 1.6(4.7)              | 0.032                |
| macrophytes        | 5.7(12)           | 20            | 1.66(2.45)                  | 3.07                  | 62(254)               | 5.7(44.8)             | 0.092                |
| entire lake        | 5.8(12)           | 34            | 1.64(2.66)                  | 2.90                  | 95(789)               | 4.0(44.8)             | 0.042                |
| Lake Kandrykul     |                   |               |                             |                       |                        |
| pelagial, 0m-bottom| 16.2(30)          | 78            | 2.66(3.76)                  | 3.78                  | 971(5.518)            | 9.6(38.5)             | 0.010                |
| pelagial, 0 m      | 15.9(25)          | 57            | 2.52(3.64)                  | 3.38                  | 1160(5.518)           | 11.0(36.2)            | 0.009                |
| open littoral      | 18.2(27)          | 78            | 2.42(3.66)                  | 3.69                  | 2315(7.362)           | 22.8(69.9)            | 0.010                |
| macrophytes        | 25.2(41)          | 108           | 2.78(3.76)                  | 3.97                  | 1979(8.978)           | 16.0(64.2)            | 0.008                |
| entire lake        | 18.1(41)          | 133           | 2.61(3.76)                  | 4.01                  | 1498(8.978)           | 14.2(69.9)            | 0.010                |

In both lakes, only 9-11% of the total number of species were found in more than half of the samples (i.e., frequency of occurrence exceeded 50%). There species were *Pelagostrombidium mirabile* (Penard, 1916), *Rimostrombidium hyalinum* (Mirabulaev, 1985), *Halteria grandinella* (O.F. Muller, 1773), *Balanion planctonicum* Foissner et al., 1994, *Askenasia* genus (*A. volvox* (Eichwald, 1852) Kahl, 1930, *A. acrostomia* Krainer & Foissner, 1990; *A. chlolligera* Krainer & Foissner, 1990); *Urotichia* spp., *Pelagohalteria viridis* (Fromentel, 1876), *Rimostrombidium lacustris* (Foissner, Skogstad & Pratt, 1988), *Codonella cratera* (Leidy, 1887) in the Lake Kandrykul, and *P. mirabile*, *R. hyalinum*, *Tintinnopsis cylindrata* Kof. & Cam., 1892, *C. cratera*, in the Lake Aslykul.

According to the Sorensen coefficient, the similarity of the species composition of ciliate communities from different ecotopes was 56-78% in the Lake Kandrykul and 51-65% in the Lake Aslykul. Higher values of the Sorensen coefficient in the Lake Kandrykul were probably due to the
development of dense underwater thickets of mare's-tail *Hippuris vulgaris* L. in most of the open water zone (down to 5-m depth and deeper), which somewhat "blurs" the border between the pelagic zone and the overgrown area of the water body. This was especially evident in 2010, when the similarity between ciliate fauna of the pelagic zone and that from the associations of higher aquatic plants was 78%. However, a significant number of species (15% of the total number of species in the Lake Asykul, 27%, in the Lake Kandrykul) were registered only in the overgrown areas of the lakes, indicating the specificity of the ciliate fauna in the shallow waters with dense macrophyte thickets.

In almost all ecotopes of both lakes, the dominant complex of ciliates steadily included *Pelagostrombidium mirabile*, which accounted for 15-55% of the total abundance in the Lake Kandrykul and 16-45% in the Lake Asykul (table 4). The ciliate community in the Lake Kandrykul was characterized by a great development of small ciliates *Balanion planctonicum* (24-34% of the abundance in different ecotopes of the lake, especially in the autumn period), and species of the genus *Urotricha* (18% of the population in overgrown shallow waters). These species usually develop together in oligo- and mesotrophic slightly alkaline water bodies [4]. Notably, they were practically absent, or occupied a minor position (less than 0.1% of the abundance) in the Lake Asykul. In this lake *T. cylindrata* (61% of total abundance) dominated in the pelagic zone, *Pelagostrombidium mirabile* (45%) in the littoral zone and *Strobilidium caudatum* (Fromentel, 1876) in the macrophyte zone (32%). The latter species usually leads a sedentary lifestyle, attaching to the substrate with a thread. The dominants by biomass were the colonial species: *Epicarchesium pectinatum* (Zacharias 1897) in the pelagic zone and open littoral zone (51% and 46% of the total biomass, respectively) and *Epistylis plicatilis* in the overgrown zone (72% of the total biomass).

3.3. General characteristics of ciliates communities in regard to different ecotopes

The ciliate communities of the studied lakes differed significantly in terms of abundance and biomass (table 3). In the Lake Asykul, ciliate abundance ranged as 8-789 cells L⁻¹ in 2010 and 4-462 cells L⁻¹ in 2012, biomass, as 0.2-44.8 µg L⁻¹ and 0.04-33.3 µg L⁻¹, respectively. In the Lake Kandrykul, ciliate abundance ranged as 36-8,978 cells L⁻¹ in 2010 and 80-8,000 cells L⁻¹ in 2012, biomass, as 0.4-64.2 µg L⁻¹ in 2010 and 0.5-69.9 µg L⁻¹ in 2012 (table 3).

**Table 4.** Main structure-forming species of ciliates (>3% of total abundance) in the lakes in 2012.

| Lake Kandrykul | Lake Asykul |
|----------------|-------------|
| **Pelagic zone** | **Pelagic zone** |
| *Balanion planctonicum* (29.2%), *Pelagostrombidium mirabile* (13.4%), *Tintinnopsis fluviatile* (7.6%), *Pelagohalteria viridis* (5.3%), *Urotricha spp.* (5.2%), *Halteria grandinella* (4.7%), *Tintinnidium spp.* (3.5%), *Tintinnopsis cylindrata* (3.0%) | *Tintinnopsis cylindrata* (51.6%), *Pelagostrombidium mirabile* (16.4%), *Codonella cratera* (8.4%), *Rimostronbidium hyalinum* (6.5%), *Pelagohalteria viridis* (5.5%), *Epicarchesium pectinatum* (5.0%) |
| **Open littoral zone (macrophyte-free)** | **Open littoral zone (macrophyte-free)** |
| *B. planctonicum* (24.5%), *P. mirabile* (15.8%), *P. viridis* (8.2%), *H. grandinella* (6.9%), *Urotricha spp.* (6.5%), *Urotricha spp.* (small-size) (4.6%), *Monodinium chlorelligerum* (3.0%) | *P. mirabile* (44.5%), *Codonella cratera* (16.2%), *E. pectinatum* (10.1%), *Halteria grandinella* (8.4%), *R. hyalinum* (7.6%), *T. cylindrata* (3.1%) |
| **Overgrown shallow waters (macrophyte thickets)** | **Overgrown shallow waters (macrophyte thickets)** |
| *B. planctonicum* (33.7%), *U. furcata* (17.7%), *R. hyalinum* (15.5%), *P. mirabile* (4.7%), *C. glaucoma* (3.5%), Hypotrichidae (3.6%) | *Strobilidium caudatum* (31.7%), *P. mirabile* (15.6%), *Vorticella spp.* (13.2%), *C. cratera* (13.0%), *R. hyalinum* (7.8%), *P. viridis* (4.5%), *E. pectinatum* (3.1%) |

In the studied water bodies, average ciliate abundance and biomass were higher in the open water zone: in the pelagic zone of the Lake Asykul and in the coastal zone visually free from macrophytes of the Lake Kandrykul (table 3, figure 3). The overgrowth of the bottom of most part of the littoral,
especially in 2010 by *Hippuris vulgaris* L., contributed to the development of favorable trophic and topological conditions for the ciliates.

Seasonal changes in the abundance of planktonic ciliates were almost opposite in the studied lakes (figure 3). In the pelagic zone of the Lake Aslykul, ciliate abundance decreased from spring to autumn, opposite pattern was observed in the Lake Kandrykul. In summer, in the whole coastal area the ciliate abundance was maximal in the Lake Aslykul and minimal in the Lake Kandrykul. In general, by 2012, the average abundance and biomass of ciliates increased in the Lake Kandrykul, and, on the contrary, decreased in the Lake Aslykul. It is quite difficult to explain this phenomenon only by external factors (such as climate changes), since the internal processes are more important.

**Figure 3.** Seasonal changes in the ciliate abundance in different ecotopes of the lakes Aslykul and Kandrykul in 2012.

### 3.4. Structural and functional peculiarities of ciliates communities in the studied lakes

#### 3.4.1. Size structure. The ciliate community of the Lake Kandrykul comprised mostly small-size species and the average mass of a cell in this lake was 3-4 times lower than that in the Lake Aslykul (table 3). The size spectra of communities clearly demonstrate this data (Figure 4). In the Lake Kandrykul, 51.5% ciliate cells were of 3,200-6,400 µm³; in the Lake Aslykul, almost 70% of the ciliate population belonged to the size class of 12,800-25,600 µm³. A small peak (5% of abundance) in the area of large species was due to the contribution of colonial species and large predators (figure 4). The size structure of the ciliate community was most influenced by ecotopic features: ciliate communities of the overgrown littoral were more diverse in size spectrum and were very different from the open water communities in the Lake Aslykul. In the Lake Kandrykul, the differences between the macrophyte zone and the open water zone were not so pronounced (figure 4).

**Figure 4.** Size spectra of plankton ciliate communities in different ecotopes of the Lake Aslykul and the Lake Kandrykul.
3.4.2. Trophic structure. The trophic structure of the ciliate community was more diverse in the Lake Kandrykul, spatial and temporal changes of ciliates abundance and biomass were synchronized. Herbivorous ciliates were dominating (49% by abundance, 58% by biomass). Predators and histophagous ciliates were represented here in greater numbers (>1% by abundance and biomass), in contrast to the Lake Aslykul. Histophagous ciliates contributed significantly both to ciliate abundance (9%) and biomass (10%) in 2010, probably, due to the active development of the macrophytes and the further process of their decomposition. In the Lake Aslykul, due to the presence of colonial species in the plankton, the community structure was very different in terms of abundance and biomass. Omnivorous ciliates dominated by abundance (39%), bacterio-detrivorous by biomass (69%). In general, the trophic structure of the community of the Lake Aslykul was less diverse and less even, especially in terms of biomass. The contribution of histophagous ciliates did not exceed 0.1%, and the biomass of predators reached only 2.2% in 2010.

The trophic structure of the ciliate community was heterogeneous across the lake areas (figure 5a). Omnivorous ciliates developed mainly in the pelagic zone of the Lake Aslykul, in contrast to the Lake Kandrykul, where all omnivorous were distributed throughout the entire water area. In the Lake Kandrykul, the trophic structure was more diverse in the shallow part. Predators (4.8% of abundance) were present in the open littoral, and histophagous ciliates (5.4%) – in the macrophyte zone, in addition to three main trophic groups listed above. In general, the trophic structure of the ciliate communities in both lakes was simplified by autumn (figure 5b).

Figure 5. Trophic structure of ciliates communities in different ecotopes of lakes (a) and its seasonal change in the water area (b).

Mixotrophic ciliates are quite widespread in natural ecosystems [4, 15, 16]. In both studied lakes, mixotrophs Pelagostrombidium mirabile, Pelagohalteria viridis, Monodinium chlorelligerum, and Actinobolina smalli developed in the open water zone. In the overgrown shallow waters, periphytone and benthic species, which came to plankton due to flushes from macrophytes and from bottom, were developed, namely Ophyrydium versatile, Vaginicola crystallina, Vorticella chlorellata, Paramecium bursaria, Stichotricha secunda, Stentor polymorphus (the Lake Kandrykul), and Epistylys plicatilis (the Lake Aslykul). The contribution of mixotrophic ciliates to the total abundance averaged as 25% in the Lake Aslykul and 20% in the Lake Kandrykul, 13% and 44% of biomass, respectively. In both lakes, the maximum contribution of this group was registered in the open littoral zone. Their role was abruptly reduced by autumn in all areas of the studied lakes. This is especially pronounced in the macrophyte zone of the lakes. For example, in the Lake Kandrykul, their contribution decreased from 75% (abundance) in spring down to 1.3% in autumn. This was probably due to the accumulation of organic matter, since the role of mixotrophic organisms decreases as the trophic level increased [17].

3.5. Ecological status of the studied lakes according to the characteristics of the ciliate community

Low abundance and biomass of plankton ciliate communities, especially in the Lake Aslykul, indicated a low trophic status of these water bodies. There was no direct correlation between the ciliate abundance and the trophic status of the lake. However, according to J R Beaver and T L Crisman [18],
the ciliate abundance in the Lake Aslykul corresponded to the ultra-oligotrophic level, in the Lake Kandrykul, to both ultra-oligo- and oligotrophic level. However, the saprobity indices (in accordance to the indicator values of ciliate species) indirectly indicate a higher trophic level. On average, the water saprobity corresponded to the upper boundary of the $\beta$-mesosaprobic zone ($S = 1.99$) in the Lake Aslykul and to $\beta$-mesosaprobic zone ($S = 2.13$) in the Lake Kandrykul. Meantime, the saprobity index in both lakes in warmer year of 2010 was higher (2.03 in the Lake Aslykul and 2.27 in the Lake Kandrykul), comparing to 2012 ($S = 1.91$ and $S = 2.09$, respectively) (table 5). Probably, the increased water temperature causes more intensive processes of production and decomposition of organic matter. But most likely, these characteristics were within the range of interannual fluctuations.

**Table 5.** Water saprobity in accordance to indicator species of ciliates in 2010 and 2012.

| Ecotope   | Pelagial | Littoral | Macrophytes | Entire lake |
|-----------|----------|----------|-------------|-------------|
|           | Lake Aslykul | Lake Kandrykul |
| 2010      | 1.97     | 1.64     | 1.94       | 2.03        |
|           |          |          |            | 2.1       |
|           |          |          |            | 2.31       |
|           |          |          |            | 2.27       |
| 2012      | 1.85     | 1.93     | 1.75       | 1.91        |
|           |          |          |            | 2.00       |
|           |          |          |            | 2.12       |
|           |          |          |            | 2.38       |
|           |          |          |            | 2.09       |

4. Discussion

By the coefficient of relative transparency (the ratio transparency/average depth was 0.42-0.97 for the Lake Kandyryk and 0.25-0.71 for the Lake Aslykul) the studied reservoirs are classified as the "planktotrophic" type, i.e. the biological transformation of matter and energy mainly takes place in the plankton community [12]. However, this conclusion for studied lakes is probably incorrect, due to high concentration of mineral suspended particles. It is supported by the relatively weak development of the plankton community (especially unicellular) in these lakes as a whole and by rather low contribution of free-living ciliates to the total plankton biomass (e.g., 0.5-1.3% in the lake Kandyryk) [13]. In total, average water transparency in the Lake Aslykul is half as much of that in the Lake Kandyryk (2 m and 4 m, respectively) [19]. Since the water transparency is mainly preconditioned by the mineral suspension, the differences in the water transparency and total mineralization of lakes (~1 g L$^{-1}$ in the Lake Kandyryk and 1.8 g L$^{-1}$ in the Lake Aslykul) are probably associated with different underlying geological material of their basins. The chemical composition of the water is a result of the discharge of calcium sulfate waters from the Ufa deposits of the Permian system in both lakes. The gypsum-anhydrite salt-bearing and anhydrite-dolomite strata of the Kungurian stage also take part in the structure of the lake catchment of the Lake Aslykul [1], which probably explains the difference in the mineralization of the lakes. In addition, differences in the conditions for hydrobionts in the studied lakes are also due to differences in the concentration of chloride ions, the amount of mineral suspension, water transparency, the degree of development of submerged macrophytes, etc.

Generally, the studied large brackish reservoirs of the Republic of Bashkortostan (lakes Aslykul and Kandyryk), which are geographically close and morphometrically similar, have a set of fairly common freshwater species that are typical for large oligotrophic and mesotrophic lakes of the world, namely, widely distributed representatives of tintinnids oligotrichs and strobilidiids [20-24]. A Smurov [25], having studied the mineralized reservoirs of the Middle Volga region, concluded that the classical brackish-water fauna is not formed at water mineralization level below 2 g L$^{-1}$, possibly due to the sulfate-calcium type of mineralization. A large role in the formation of brackish-water and marine fauna probably belongs to chloride ions. Our data confirm this conclusion. For example, the studied plankton communities are similar by quantitative characteristics to the communities of plankton ciliates in a large mountain reservoir, the Lake Sevan, where the ciliate abundance ranges as 32-1,483 cells L$^{-1}$, biomass, 1.2-162.9 mg m$^{-3}$ [26], and to the communities of the brackish water bodies of the Vyatka elevation (137 cells L$^{-1}$) [27] and some others. However, the differences in water mineralization, weak development of the macrophyte zone, and the absence of submerged aquatic plants in the Lake Aslykul explain the differences in the total quantitative and structural characteristics of the communities of two lakes. In the Lake Aslykul, the number of species is 3.8 times lower, abundance 15.8 times lower, biomass 3.6 times lower, but the average cell mass is 4 times higher than
those in the Lake Kandrykul (table 3). In addition, the lakes differ in the degree of phytoplankton development and the concentration of chlorophyll $a$ (0.77 $\mu$g L$^{-1}$ in the Lake Aslykul and 2.05 $\mu$g L$^{-1}$ in the Lake Kandrykul), in the total phosphorus concentration (on average, 25 $\mu$g P L$^{-1}$ and 32 $\mu$g P L$^{-1}$, respectively) [19], which probably leads to the differences in the average cell size and trophic structure of the entire community. In the Lake Aslykul, large (colonial) ciliate species dominate; and bacteriophagous dominate by biomass in the trophic structure. It is possible that colonial plankton species have an advantage over single cells in more efficient assimilation of resources in the conditions of limited productivity. The mobility of colonial species in plankton also contributes to this, as the rate and volume of filtered water increases. When comparing with higher trophic conditions, for example, with the communities of active silt, colonial species reach here high abundance, but they lead attached lifestyle only. As reported in [24] low chlorophyll concentration restricts mainly the development of herbivorous and omnivorous species. Perhaps, that is why the biomass of herbivorous and omnivorous totaled 72.6% in Lake Kandrykul and only 29.8% in the Lake Aslykul, where the average concentration of chlorophyll is almost three times lower. Compared to 2010, the changes in the size spectra and trophic structure of ciliate communities in 2012 most likely fit into the range of natural fluctuations in both lakes. The size spectra, despite the observed changes in the species structure, are fairly stable over time, so they were almost the same in 2010 and 2012, supported by the published data on the stability of the size structure of zooplankton over a long time period [28].

It should be noted that higher anthropogenic impact may be named as one of the reasons for the low species diversity and low abundance of ciliates in the Lake Aslykul. The higher openness index in the Lake Aslykul (table 1) indirectly confirms the probability that this lake is more affected not only by climatic factors, but also by the increasing and poorly controlled recreational load in the lake's catchment area, which may have negative consequences for this lake in the future.

5. Conclusion
A comparative analysis of the ciliate communities of two large lakes of the Republic of Bashkortostan evidenced that the ciliate fauna of the Lake Aslykul was less representative, in contrast to the fauna of the Lake Kandrykul. Low species diversity and ciliate abundance in the Lake Aslykul was probably caused by increased mineralization, by a large amount of mineral suspension, and by the absence of a well-developed zone of submerged aquatic plants. The structural and functional peculiarities of ciliate communities were probably related to the differences in the concentration of phosphorus and chlorophyll $a$. So, in a more trophic Lake Kandrykul the cell size spectrum was shifted towards smaller species and the trophic spectrum was shifted towards an increase in the share of herbivorous and omnivorous species. The first data obtained on the free-living ciliates of these hydrological natural monuments may serve as a starting point for assessing the changes and monitoring their ecological state in the future.

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