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Biomonitoring of antropogenic contamination of Absheron coast of the Caspian Sea at the level of planktonic ciliate communities

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Summary

A study of planktonic ciliate species diversity in the Caspian littoral of Absheron was conducted in 2014–2018. Fifty-seven ciliate species belonging to 21 families were revealed. A correlation has been established between the planktonic ciliates' species richness and the organic pollution degree at the coastal zone. The status of some ciliate species as indicators of varying saprobity was clarified. The most precise indication using ciliates was obtained for alpha-meso and alpha-polysaprobic zones. We explain this fact by the more accurate data on ciliates - indicators of more polluted zones and the erroneous certification of many ciliate species, currently considered as indicators of beta-alpha-mesosaprobic zone.

Key words: Absheron coast, anthropogenic pollution, Caspian Sea, ciliates, plankton

Introduction

The Caspian Sea is the largest intracontinental salty-water basin which has no connection with the World Ocean; nonetheless, this water basin possesses all characteristics of the sea. The modern study of ciliates of the Caspian Sea was begun in the middle of the last century by F. Agamaliev, who summarized results of the long-term research in his monograph (Agamaliev, 1983). Faunistic research and environmental studies of the free-living ciliates of the Caspian Sea, including plankton community, were conducted regularly in the following decades (Alekperov and Aliyev, 1996; Alekperov and Asadullayeva, 1999; Alekperov et al., 2017).

For many years, the species diversity of the Caspian plankton has been under the anthropogenic stress resulting from long-term contamination of the Caspian Sea due to oil exploration and drilling. As a result, these activities have led to strong hydrocarbon contamination in many aquatorias of the Absheronian coast.

The problem caused by contamination of Absheron coast of the Caspian Sea is still relevant, despite the fact that in the recent years the level of anthropogenic pressure was significantly reduced. At the present time, the sewage water contamination is becoming increasingly important due to the sharply increased of Absheron urbanization.

Free-living protozoa, primarily ciliates, respond extremely quickly, qualitatively (by changing species composition) and quantitatively (by changing population densities), to the slightest alterations in the environment, including the technogenic

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contamination. This feature of ciliates makes it possible to use them for bioassay of contamination degree of a particular marine and freshwater bodies.

We carried out a comparative assessment of the species diversity of planktonic ciliates in different parts of the Absheron coast and fulfilled a preliminary assessment of the environmental quality based on the ciliate community changes.

Material and methods

Samples were taken monthly, during 2014–2018 at 6 stationary collection points in the Absheron coast of the Caspian Sea (Fig. 1). In total, 120 plankton samples were collected and processed. The impregnation methods with silver nitrate (Chatton and Lwoff, 1930) and protargol (Alekperov, 1992) were widely used for taxonomical determination of ciliates. All measurements and photomicrographs were taken using an Olympus light microscope. The common ecological indices (i.e. Simpson and Margalef) were used to assess the state of planktonic ciliate communities, and the Bray-Curtis cluster analysis was used to compare the similarity of different coastal parts. Ciliate species as to indicators of different saprobity zones were classified on the basis of our long-term research, taking into account the available publications (Foissner et al., 1991; Alekperov, 1996).

Results and discussion

In total, 57 ciliate species belonging to 21 families were found in the planktonic communities of the coastal waters of Absheron. The ciliate species composition and and their occurrence at different collection points are shown in Table 1.

As seen from Table 1, the highest species richness of planktonic ciliates was observed at the coast of Novkhani (36 species) and Bilgah (35 species). A fairly high species diversity was observed also in the area of Sangachal (25 species) and at the coast of Shikhov (21 species). The minimum number of species was observed in the plankton communities in the areas of Sumgayit and Turkan: in both cases, only 18 species of plankton ciliates were found. It should be noted that a significant difference between the Northern and Southern Absheronian coasts is primarily expressed in the cleanliness of the coastal zone.The Northern coast is less contaminated with

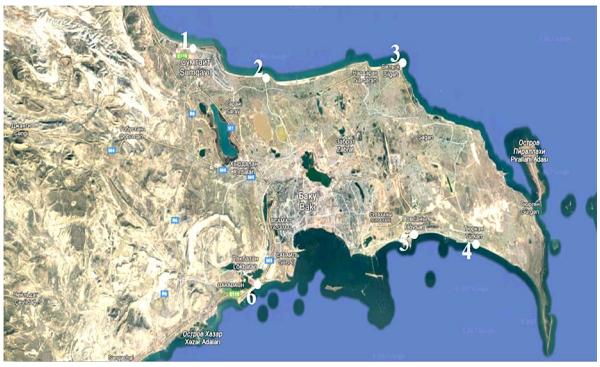

Fig. 1. Stationary plankton collection points on the Absheron coast. 1 – Sumgayit, 2 – Novkhani, 3 – Bilgah, 4 – Turkan, 5 – Shikhov, 6 – Sangachal.

both marine oil drilling products and domestic sewage waters. On the Northern coast, there are still areas of pure psammon, and in the coastal zone there are many stones with well-developed periphyton.

The southern coast in some places is heavily polluted by drilling products of the offshore oil wells (although in recent years the results of increased monitoring of the cleanliness of the sea have become noticeable), but the main problem is related to the discharge of the major part of all domestic wastewaters at the southern coast.

In Fig. 2, the results of cluster analysis of the similarity of species diversity of the communities of planktonic ciliates in different areas of the Absheron coast are presented. As can be seen from Fig. 2, the greatest similarity of species diversity (95.5%) was observed between two collection points on the northern coast of Absheron - in the settlements Novkhany and Bilgah. This part of the Absheron Peninsula is traditionally the cleanest, despite the permanent process of construction of hotels and private houses there.

A comparison of more polluted areas showed the highest similarity of planktonic ciliate species diversity between the Sumgayit and Sangachal coasts (65%). Despite the considerable distance from each other, both zones are under quite strong pressure from industrial pollution - in Sumgayit these are remnants of perennial discharges in the industrial zone, while in Sangachal there is quite noticeable general pollution with both oil and wastewaters of the largest oil terminal.

The similarity of these two points with the point on the coast of Turkan is somewhat less (61%). In principle, this latter zone belongs to a fairly clean area, although during the period of winds from

Table 1. Species composition and distribution of free-living ciliates at stationary collection points of the Azerbaijan sector of the Caspian coast.

Taxonomic composition of planktonic ciliates at the Absheron coast of the Caspian Sea		Occurrence at the collection points*					
		1	2	3	4	5	6
	Phylum Ciliophora Doflein, 1901						
	Fam. Euplotidae Ehrenberg, 1838						
1	*Euplotes apsheronicus* Agamaliev,1966		+	+	+	+	
2	*E. balteatus* Dujardin, 1842	+			+		+
3	*E. charon* (Müller, 1786)	+			+		+
4	*E. gracilis* Kahl, 1932		+	+			
	Fam. Aspidiscidae Ehrenberg, 1838						
5	*Aspidisca fusca* Kahl, 1928	+			+	+	+
6	*A. poljanski* Alekperov,1985		+	+			
	Fam. Uronychiidae Jankowski, 1975						
7	*Diophrys scutum* Dujardin, 1841	+			+	+	+
	Fam. Halteriidae Clap. et L., 1858						
8	*Halteria grandinella* (Müller,1786)		+	+	+		
9	*Pelagohalteria viridis* (Fromentel,1876)		+	+		+	
	Fam. Strombidiidae Faure-Fremiet, 1970						
10	*Limnostrombidium viride* (Stein,1867)		+	+			+
11	*Novistrombidium testaceum* (Anigstein,1914)		+	+			
12	*Spirostrombidium apsheronicum* Alekperov et Asad.,1997		+	+			
13	*S. caspicum* Alekperov et Asadullayeva,1997		+	+			+
14	*S. cinctum* Kahl,1932					+	+
15	*S. conicoides* (Leegaard,1915)		+	+			
16	*S. elatum* Alekperov,1985		+	+			
17	*S. elegans* Florentin, 1899					+	
	Fam. Strombidinopsidae Small et Lynn, 1985						
18	*Strombidinopsis azerbaijanica* Alekperov et Asad., 1997		+	+			+
19	*S. claparedi* Kent,1881					+	
20	*S. elegans* Song et Bradbury,1998						+
21	*S. elongata* Song et Bradbury, 1998		+	+			
	Fam. Strobilidiidae Kahl in Doflein et Reich., 1929						
22	*Rimostrombidium velox* Faure-Fremiet, 1924		+	+			
23	*R. humile* Penard, 1922		+				
	Fam. Lacrymariidae Fromentel, 1876						
24	*Lacrymaria olor* (Muller, 1786)	+					+
25	*Phialina macrostoma* Foissner, 1983				+		+
	Fam. Didiniidae Poche, 1913						
26	*Didinium chlorelligerum* Kahl, 1935				+		
27	*D. gargantuan* Meinier, 1907		+	+			
28	*D. nasutum* (Muller, 1773)	+	+	+			
29	*Monodinium balbianii* Fabre-Dom., 1888	+			+		+
30	*M. perrieri* Delphy, 1925		+	+	+		
	Fam. Trachelidae Ehrenberg, 1838						
31	*Paraspathidium obliquum* Dragesco, 1963	+			+		+
32	*P. fuscum* Kahl, 1928	+			+		+

Table 1. (Continuation).

Taxonomic composition of planktonic ciliates at the Absheron coast of the Caspian Sea		Occurrence at the collection points					
		1	2	3	4	5	6
	Fam. Mesodiniidae Jankowski, 1980						
33	*Mesodinium acarus* (Clap. et Lach., 1859)		+				
34	*M. apsheronicum* Alekperov et Asad., 1996		+	+	+		
35	*M. cinctum* Kahl, 1930		+	+			
	Fam. Nassulidae Fromentel, 1874						
36	*Nassula marina* Alekperov et Asadullaeva, 1997		+	+	+		
	Fam. Colepidae Nitzsch, 1827						
37	*Coleps arenicolus* Dragesco, 1965	+				+	
38	*C. lacustris* Faure-Fremiet, 1924	+			+	+	+
39	*C. nolandi* Kahl, 1930	+	+	+		+	
40	*C. remanei* Kahl, 1933	+			+	+	+
	Fam. Urotrichidae Small et Lynn, 1985						
41	*Urotricha armata* Kahl, 1927		+	+			+
42	*U. farcta* Clap. et Lach., 1859			+		+	
43	*U. pelagica* Kahl, 1932		+	+			
	Fam. Parameciidae Dujardin,1840						
44	*Paramecium putrinum* Clap. et Lach.,1858	+			+	+	+
45	*P. woodruffi* Wenrich, 1928	+				+	+
	Fam. Cyclidiidae Ehrenberg, 1838						
46	*Caspionella bergeri* (Agamaliev, 1972)					+	+
47	*C. marinum* Borror, 1963		+	+			
48	*Cristigera fusiformis* Penard, 1922		+	+			
49	*C. vestita* Kahl, 1928		+	+			
	Fam. Uronematidae Thompson, 1964						
50	*Uronema acutum* Buddenbrock, 1920		+	+		+	+
51	*U. marinum* Dujardin, 1841	+				+	+
	Fam. Pleuronematidae Kent, 1881						
52	*Pleuronema coronatum* Kent, 1881		+	+		+	+
53	*P. marinum* Dujardin, 1841		+	+		+	
	Fam. Epistylidae Kahl, 1933						
54	*Epistylis nympharum* Engelmann, 1862		+	+		+	
	Fam. Vorticellidae Ehrenberg, 1838						
55	*Carchesium umbilicatum* Stiller,1941	+	+	+		+	
56	*C. wassenum* Viljoen et Reinecke, 1988		+	+			+
	Fam. Zoothamniidae Sommer, 1951						
57	*Zoothamnium marinum* Mereschekowski,1877	+	+	+	+		+
	Total number of species at collection points:	**18**	**36**	**35**	**18**	**21**	**25**

* ***Note***. 1 – Sumgayit, 2 – Novkhani, 3 – Bilgah, 4 – Turkan, 5 – Shikhov, 6 – Sangachal.

the sea it is also, like the entire southern coast of Absheron, subject to pollution from both by oil drilling products and domestic wastewaters. Comparison of these sites with the coast of the Shikhov settlement also showed their rather large similarities (51.2%), since this site has the same causes of pollution as the entire southern coast of the Absheron Peninsula.

Comparison of ciliates species diversity of plankton communities across all six stationary collection points at Absheron showed that its overall similarity cannot be called high (32.7%).

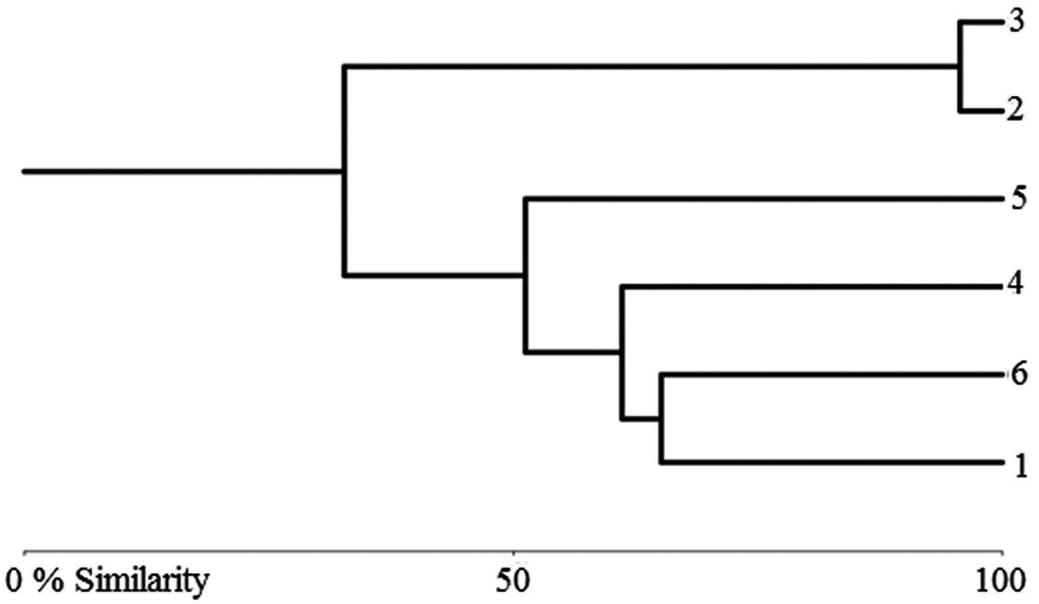

Fig. 2. The similarity of planktonic ciliate species diversity in different parts of Absheron coast of the Caspian Sea: 1 – Sumgayit, 2 – Novkhani, 3 – Bilgah, 4 – Turkan, 5 – Shikhov, 6 – Sangachal.

Thus, the analysis showed that two clusters of planktonic ciliate species are distinguished at the coast of the Absheron Peninsula. One of them unites the cleanest areas of the settlements Novkhani and Bilgah (95.5%), and the second one covers all the other 4 fixed collection points. At the same time, the similarity within the second cluster for all sites is more than 50%. It is characteristic that the cluster combining the more contaminated areas included all collection points on the southern coast of the Absheron Peninsula, with the exception of the coast of Sumgayit, which has been known since the Soviet times as a zone of strong technogenic contamination.

We also compared the ratio of ciliates - indicators of different zones of saprobity in each of the six fixed collection points. It goes without saying that the results we obtained are preliminary, since the specialists have not yet reached an agreement on whether a particular ciliate species can be considered as an indicator of a certain saprobity zone. This is due to the high ecological plasticity of many ciliate species and, mainly, due to difficulties in determining their taxonomic identity. It is known that at present the taxonomic identification of ciliates is mainly based on the structure of their infraciliature, which is detected only in total preparations impregnated with silver. Therefore, in our analysis we used the literature data that were obtained exclusively using modern methods for the identification of ciliates.

Fig. 3 shows the ratio of planktonic ciliates as indicators of different saprobity zones at the collection points of the coast of the Absheron Peninsula.

As can be seen from Fig. 3 that in general, the sanitary condition of the Absheron Peninsula water area is assessed as satisfactory, with a predominance of ciliates – indicators of the mesosaprobic zone. However, the quality of water at different sites has significant differences. For example, the lowest share of indicators of the purest beta-mesosaprobic zone were 18% in Shikhov and Sangachal, 22% in Sumgayit, while the highest values were registered in Turkan (48%) and especially in Novkhani (68%) and Bilgah (55%).

The proportion of representatives of the higher degree of saprobity, indicator species of the beta- and alphamesosaprobic zone, ranged from 16% (Sumgait and Sangachal sites) to 22% (Novkhani) and 32% (Turkan).

The most notable values were found for alpha and alpha-polysaprobic zones. According to the ratio of ciliates – indicators of the alpha-mesosaprobic zone, the Shikhov (45%), Sangachal (44%) and Sumgayit (38%) sites were in the lead. The percentage of alpha-mesosaprobes at the three other collection points was significantly lower. For example, in the collection points of Novkhany and Turkan, they amounted, respectively, 8% and 10%, and in the Bilgah zone – 12%.

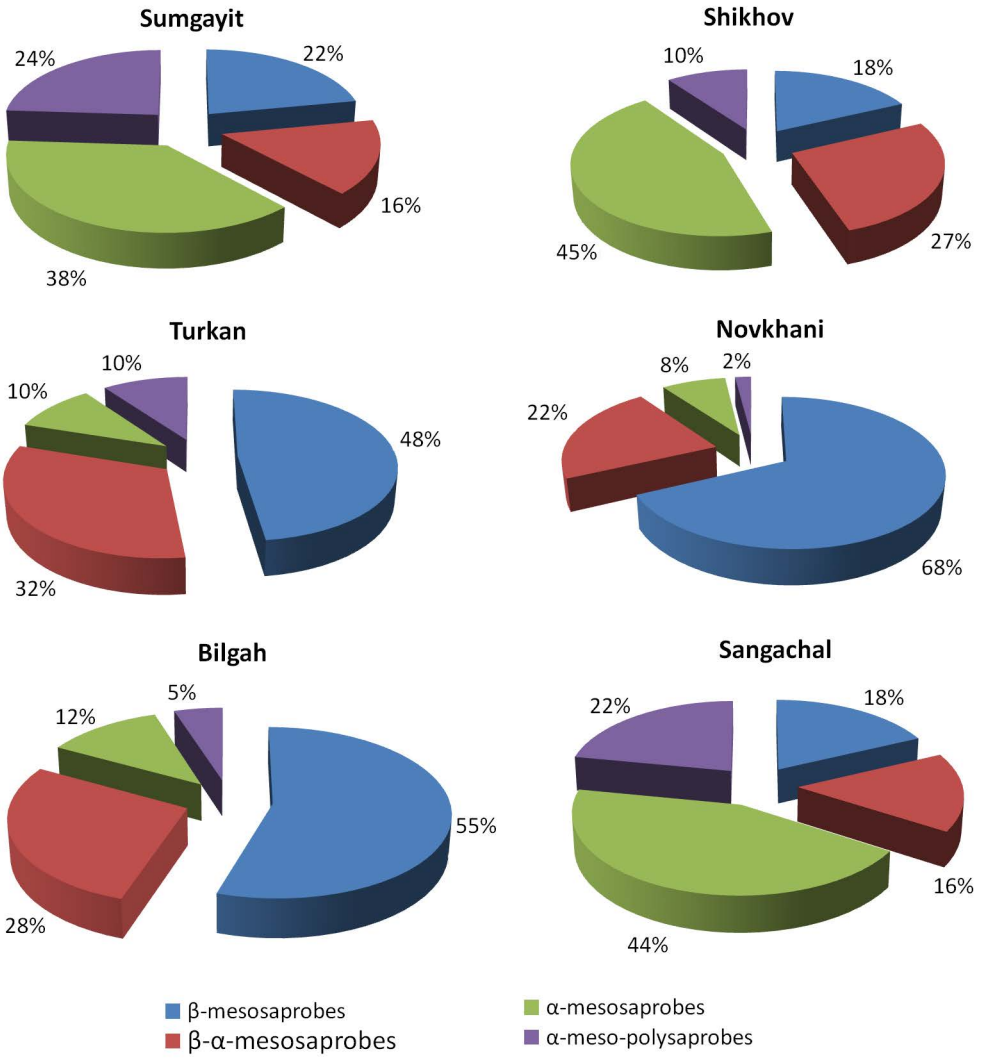

Fig. 3. The ratio of ciliates as indicators of saprobity at different collection points (averaged for 2016-2018).

Similar results were obtained for ciliates – indicators of the most contaminated alpha-polysaprobic zone. As can be seen from Fig. 3, their highest percentage was observed on the coasts of Sangachal (22%) and Sumgayit (24%). In the areas of Shikhov and Turkan, indicators of this zone constituted 10%, and their minimum values were noted for the cleanest waters of the Caspian Sea coast, Bilgah (5%) and Novkhani (2%).

Therefore, summing up the data, we can draw the following conclusions:

1. The degree of pollution of aquatic habitats to a certain extent "correlates" to the diversity (number) of species in the communities of planktonic ciliates. In the most clean areas of the Absheron Peninsula (Novkhany and Bilgah), the greatest number of ciliate species was noted – 36 and 35, respectively. In the remaining more polluted areas, the ciliate species numbers did not exceed 18-25.

2. The degree of organic pollution affects the similarity of the species composition in the plankton ciliate communities. This is evident from the data of similarity cluster analysis of species diversity of planktonic ciliates in various parts of the Absheron coast of the Caspian Sea. This analysis showed the presence of two clusters, one of which revealed the similarity of the purest areas of Novkhani and Bilgah at the level of 95.5%, and the second united the remaining four collection points (Sumgayit, Turkan, Shikhov and Sangachal). The similarity of their species diversity was 51.2 - 65%.

3. Evaluation of the data on the ratio of ciliates – indicators of various zones of saprobity in different coastal regions suggests that Novkhani

and Bilgah are the cleanest areas of the Absheron coast of the Caspian Sea. Contamination was most clearly revealed by indicators of the alphameso- and alphapolysaprobic zones. We explain this by the more accurate data on ciliates – indicators of contaminated zones, and inconsistencies in the certification of many species of ciliates that are currently classified as indicators of the cleaner waters in beta- and alphamesosaprobic zones.

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