

Conference Paper

Assessment of Freshwater Bodies in Murmansk in Terms of Composition of Aquatic Invertebrates

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Abstract

The paper presents the results of analysis of hydrobiological samples of freshwater bodies of Murmansk (Lake Okunevoe, Lake Ledovoje and Lake Semyonovskoe). The number, degree of dominance and frequency of occurrence of organisms are determined. In Lake Ledovoje, the dominant species represent small organisms with simple life cycles and a high rate of reproduction. The taxonomic composition of water invertebrate community in the Lake Ledovoje highlights features of anthropogenic eutrophication. Several dominant species stand out in the ciliatocenosis of the Lake Okunevoe. The species diversity of micrzooplankton community is higher than in the Lake Ledovoje. In general, the Lake Okunevoe can be characterized as a water body with signs of ecosystem stability damage. The hydrobiocenoses of the Lake Semyonovskoe has the greatest species diversity. However, it is characterized by the tendency to decrease the species composition of organisms -- indicators of clean waters. There are initial signs of anthropogenic eutrophication of the Lake Semyonovskoe. The waters of the studied lakes are characterized as β -mesosaprobic (moderately contaminated). It is generally noted that the fauna of water bodies is characterized by small species diversity. In lakes there is a prevalence of small-sized organisms of heterotrophic nutrition. There is a stable decreasing tendency of species composition of hydrobionts and simplification of food chains in urban aquatic ecosystems subject to anthropogenic impact.

Keywords: freshwater bodies, saprobity, aquatic invertebrates, anthropogenic eutrophication

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1. Introduction

The quality of small subarctic water bodies and functioning of their ecosystems is developed in specific natural and climatic conditions. Water bodies can significantly differ in genesis, landscape position, geological structure of water collection area, hydrological conditions and other factors [1]. Anthropogenic factors also play a significant role in the formation of surface water quality.

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Water quality of subarctic water bodies is rapidly deteriorating due to low resistance to external impacts, unsustainable use, global and local changes in the environment and climate. The vulnerability of freshwater ecosystems is caused by the fact that they integrate all changes in their water collection areas and accumulate most of the pollutants. Biodiversity of northern water bodies is very sensitive to climatic changes, disruption of hydrological regime, deterioration of water quality and introduction of new species [2, 3].

Water bodies and watercourses located in the urban area are subject to chronic anthropogenic impact. The sources of pollution may include industrial and household waste water, surface runoff from adjacent areas, household and industrial wastes, aerotechnogenic pollution. The antropogenic impact reduces species diversity and biological productivity, makes the trophic structure simpler, deteriorates the recreational value of urban water bodies. The inventory of biotic community of aquatic invertebrates of small subarctic water bodies is critical to assess and preserve the biodiversity of hydrofauna [4].

The purpose of the study: to give an assessment of the state of freshwater bodies of Murmansk in terms of biotic components.

Objectives: to determine the taxonomic composition of organisms living in the littoral zone of urban lakes; to calculate the degree of dominance and occurrence of hydrobionts; to assess the degree of prosperity of ecosystems within the studied water bodies.

2. Methods and Equipment

2.1. Methods

The study presents the results of the analysis of seasonal hydrobiological samples of the Lake Ledovoe, the Lake Okunevoe and the Lake Semyonovskoe taken in 2015-2016. In each lake 1 station was selected for the collection of hydrobiological samples. The main criteria for the selection of stations were the type of soil and the level of anthropogenic load. Sampling was carried out in shallow water bodies at a depth of 0.2-0.5 m using a glass (plastic) container of 1000 ml.

The samples were taken both in the thickness and the bottom layer by screwing a container into soil. Then the sample was concentrated by taking the upper supernatant layer of water with a rubber bag pipette. To prevent organisms from getting into the filtrate, the free end of the pipette was tightened with mill gas. The concentrated sample

was analyzed in the Bogorov chamber. Soil samples were washed through a 0.25 mm mesh screen and analyzed in the Bogorov chamber or the Petri dish. The cameral treatment of water and soil samples was performed via direct microscopy of unfixed samples [5]. The taxonomic names of organisms are given according to the *Definitions of Limnetic Invertebrate Zooplankton and Zoobenthos of Fresh Waters of the European Russia* [6, 7]. The number of invertebrates was identified using a manual [8]. The degree of species dominance (P_i) was determined by the formula:

$$P_i = \frac{n_i}{N} \times 100\%,$$

where n_i -- number of individuals of this species in a sample; N -- total number of organisms in the sample.

The degree of dominance was assessed qualitatively by the following gradations [9]:

$P_i > 20\%$ -- dominant species "+++";

P_i ranges from 19% to 9% -- common species "++";

$P_i < 9\%$ -- rare species "+".

The frequency of organisms was calculated according to the following formula:

$$V = \frac{a}{A} \times 100\%$$

where a -- number of samples containing the given species; A -- total number of samples in a given biotope.

The water saprobity (S) was determined by the Pantle-Buck saprobity index (modified by Sladeczek) [10]:

$$S = \frac{\sum sh}{\sum h}$$

where s -- species indicator value; H -- frequency of hydrobionts occurrence, % or points.

The calculations were subjected to statistical processing.

3. Results

Lake Ledovoe. The area of the lake is 0.053 km². The average depth is 7.4 m, the inmost depth is 15 m. The length of the lake is 0.33 km, the maximum width is 0.25 km. The Varnichny stream flows from the lake.

Along the shoreline of the water body there are several motor transport enterprises that can ensure industrial and storm waste water disposal. A large road transport highway, Kola Prospect, has an aerotechnogenic effect on the water ecosystem of the lake.

In the seasonal samples of 2015-2016, 37 species and forms of aquatic organisms were identified.

The degree of dominance (P_i) and frequency of occurrence of organisms (V) are shown in Table 1.

During the study of the Lake Ledovoe 18 representatives of cili fauna were registered, among which the most frequent are *Coleps cf. hirtus*, representatives of *Aspidisca* and *Vorticella*. The dominant species in the ciliatocenosis is *Coleps cf. hirtus*. The subdominants were the infusoria *Paramecium* sp., *Oxytricha* sp., *Stylonichya cf. mytilus*, *Dileptus cf. anser* and the members of the *Prorodon*. *Spirostomum* sp. and *Stentor cf. roeseli* are quite often met. The members of *Lacrymaria*, *Amphileptus*, *Stichotricha* and *Holophrya* are rarely found in the samples of cili fauna species. The dominance of *Coleps cf. hirtus*, *Aspidisca* sp. and *Vorticella* sp. can be attributed to their high competitiveness and wide range of tolerance to environmental aquatic factors.

The rotifers belonging to *Brachionidae*, *Filinidae*, *Synchaetidae* families form the basis of microzooplankton community. The taxonomic composition of rotifers reaches 13 species and forms.

Among entomostracans the typical representatives of limnoplankton are cladocerans (*Chydorus* sp.) and copepods (*Cyclops* sp.).

In bottom samples the standard representatives of zoobenthos include oligochaetes and nematodes.

The abundance of small infusoria *Coleps cf. hirtus*, mass development of rotifers of *Brachionidae*, *Filinidae*, as well as small cladocerans are signs of pollution and anthropogenic eutrophication of the Lake Ledovoe.

The value of the saprobity index (S) makes 2.06 ± 0.14 (β -mesosaprobic waters).

Lake Okunevoe. The water basin is located in the eastern part of the city of Murmansk. It stretches in the direction from north to south. The drain from the lake is ensured through a stream.

On the northern side of the lake there is a garage town, from which melt and rain waters flow to a marshland. Sedge vegetation serve as a powerful filter and prevent direct entry of pollutants into the lake. From the west and the east, the lake is surrounded by mud cones, no direct anthropogenic impact has been detected. The southern side of the lake represents a grass swamp overgrown with sphagnum moss, sedge and cotton grass.

TABLE 1: Degree of dominance and frequency of hydrobionts occurrence in the Lake Ledovoe.

n/n	Taxon	Degree of dominance (Pi), %	Frequency of occurrence (V), %
1	<i>Coleps cf. hirtus</i>	+++	87.5
2	<i>Holophrya</i> sp.	+	12.5
3	<i>Lacrymaria</i> sp.	+	12.5
4	<i>Prorodon</i> sp.	+	50.0
5	<i>Chilodonella</i> sp.	+	25.0
6	<i>Dileptus cf. anser</i>	+	50.0
7	<i>Amphileptus</i> sp.	+	12.5
8	<i>Paramecium cf. bursaria</i>	+	75.0
9	<i>Paramecium</i> sp.	+	50.0
10	<i>Stentor cf. polymorphus</i>	+	25.0
11	<i>S. cf. roeseli</i>	+	25.0
12	<i>Spirostomum cf. minus</i>	+	50.0
13	<i>Bursaria cf. truncatella</i>	+	25.0
14	<i>Aspidisca</i> sp.	++	100.0
15	<i>Oxytricha</i> sp.	+	50.0
16	<i>Stylonichya cf. mytilus</i>	+	25.0
17	<i>Stichotricha</i> sp.	+	12.5
18	<i>Vorticella</i> sp.	++	87.5
19	Nematoda indet.	+	62.5
20	Gastrotricha indet.	+	25.0
21	<i>Filinia</i> sp.	+++	87.5
22	<i>Trichocerca</i> sp.	+	12.5
23	<i>Asplanchna</i> sp.	+	12.5
24	<i>Enteroplea cf. lacustris</i>	+	25.0
25	<i>Synchaeta cf. pectinata</i>	+	37.5
26	<i>Epiphanes</i> sp.	+	12.5
27	<i>Habrotrocha</i> sp.	+	25.0
28	<i>Rotaria cf. rotatoria</i>	+	12.5
29	<i>Philodina</i> sp.	+	12.5
30	<i>Mytilina</i> sp.	+	12.5
31	<i>Brachionus</i> sp.	++	87.5
32	<i>Keratella cf. quadrata</i>	++	87.5
33	<i>Tubifex cf. tubifex</i>	++	50.0
34	Oligochaeta indet.	+	12.5
35	<i>Chydorus</i> sp.	+	87.5
36	<i>Cyclops</i> sp.	+	87.5
37	<i>Eristalis cf. tenax</i>	+	12.5

TABLE 2: Degree of dominance and hydrobiotics occurrence in the Lake Okunevoe.

n/n	Taxon	Degree of dominance (Pi), %	Frequency of occurrence (V), %
1	<i>Peridinium</i> sp.	+	50.0
2	<i>Coleps</i> cf. <i>hirtus</i>	++	50.0
3	<i>Prorodon</i> sp.	+	12.5
4	<i>Dileptus</i> cf. <i>anser</i>	+	50.0
5	<i>Amphileptus</i> sp.	+	75.0
6	<i>Paramecium</i> cf. <i>bursaria</i>	+	12.5
7	<i>P.</i> cf. <i>caudatum</i>	+++	50.0
8	<i>Paramecium</i> sp.	+++	50.0
9	<i>Stentor</i> cf. <i>polymorphus</i>	+	25.0
10	<i>S. roeseli</i>	+	12.5
11	<i>Spirostomum</i> cf. <i>minus</i>	+	50.0
12	<i>Aspidisca</i> sp.	+	50.0
13	<i>Oxytricha</i> sp.	+	12.5
14	<i>Stylonichya</i> cf. <i>mytilus</i>	+	25.0
15	<i>Vorticella</i> sp.	++	87.5
16	Nematoda indet.	+	62.5
17	Gastrotricha indet.	+	12.5
18	<i>Filinia</i> sp.	+	50.0
19	<i>Asplanchna</i> sp.	+	25.0
20	<i>Enteroplea</i> cf. <i>lacustris</i>	+	37.5
21	<i>Synchaeta</i> cf. <i>pectinata</i>	+	87.5
22	<i>Epiphanes</i> sp.	+	50.0
23	<i>Habrotrocha</i> sp.	+	12.5
24	<i>Brachionus</i> sp.	+	25.0
25	<i>Kelicottia</i> cf. <i>longispina</i>	+	12.5
26	<i>Keratella</i> cf. <i>quadrata</i>	++	75.0
27	Lumbriculidae indet.	+	12.5
28	Oligochaeta indet.	+	25.0
29	<i>Chydorus</i> sp.	+	50.0
30	<i>Daphnia</i> sp.	+	12.5
31	<i>Sida</i> sp.	+	25.0
32	<i>Cyclops</i> sp.	+	37.5
33	<i>Diaptomus</i> sp.	+	25.0
34	<i>Chyronomus</i> sp.	+	25.0

34 taxonomic groups were identified in hydrobiological samples of the Lake Okunevoe in 2015-2016. The degree of dominance (*Pi*) and frequency of occurrence of organisms (*V*) are shown in Table 2.

Lake samples demonstrated a high occurrence rate (50% of samples) of *Peridinium* sp. (Pyrrophyta order).

The number of taxons of ciliatofauna is 17. In terms of the degree of dominance and the frequency of occurrence, the infusoria of *Paramecium*, *Coleps*, *Vorticella* hold the leading positions (indicators of the alpha- and beta- mesosaprobic zone). In general, monodomination was not revealed in ciliatocenosis, which is typical for systems under stable environmental conditions.

Microzooplankton is represented by rotifers of Brachionidae, Synchaetidae, Filinidae families. *Synchaeta cf. pectinata* and *Keratella cf. quadrata*, the representatives of Asplanchnidae family, are quite often met. The previous studies (2010-2012) show the presence of rotifers of Colurellidae family -- *Rotatoria colurella colurus* in hydrobiological samples of the Lake Okunevoe. Colurellidae -- *Rotatoria colurella colurus*. Such species of rotifers as *Synchaeta tremula*, *Epiphanes brachionus*, *Epiphanes senta*, *Rotatoria tardigrada*, etc. were also identified. A colonial form of rotifers *Conochilus unicornis* was discovered [11]. In 2015-2016 the species wealth of rotifers was decreased compared to the previous period of the study.

The typical representatives of copepods in the samples of the Lake Okunevoe are *Cyclops* sp. and *Diaptomus* sp. Among cladocerans the maxillopods of Chydoridae, Sidaidae, Daphniidae families are often found.

Oligochaetes do not form mass clusters. In the samples of 2010-2012 there were caddis worms of Goeridae and Phryganeidae families [11, 12], which can be classified as indicators of pure waters. In 2015-2016, the representatives of Trichoptera order were not found.

The saprobity index of the Lake Okunevoe makes 1.71 ± 0.06 (β -mesosaprobic waters).

Lake Semyonovskoe. It is located in the northern part of Murmansk. The water flows through the stream Semyonovskii to the Kola Bay. The area of the lake is 0.065 km². The size of the lake is 580x780 m. The volume is 14203 m³. The average depth is 4.0 m, the inmost depth is 17 m. The height of the lake above sea level is 97.5 m.

The sources of anthropogenic impact on the lake are as follows: surface runoff, aerotechnogenic pollution, recreational load.

In 2015-2016, 50 taxonomic groups were identified in hydrobiological samples of the Lake Semyonovskoe. The degree of dominance (*Pi*) and frequency of occurrence of organisms (*V*) are shown in Table 3.

The ciliatocenosis of the Lake Semyonovskoe is represented by 22 species and forms. In terms of the degree of dominance and frequency of occurrence there are

Coleps cf. hirtus, *Paramecium cf. caudatum* and *Vorticella* sp. The often met infusoria include *Dileptus cf. anser*, *Amphileptus* sp., *Paramecium cf. bursaria*, *Spirostomum* sp., *Aspidisca* sp., *Oxytricha* sp. There is a high variety of hypotrichs: *Oxytricha* sp., *Stylonichya cf. mytilus*, *Euplotes* sp., *Aspidisca* sp., *Colpoda* sp. Among rare organisms there are *Uroleptus cf. piscis*, *Loxodes cf. rostrum*, *Loxophyllum cf. meleagris* belonging to alpha- and beta- mesosaprobic organisms. In general, the ciliatocenosis of the Lake Semyonovskoe is characterized by the greatest species wealth. No mass abundance of infusories was detected.

Microzooplankton consists of rotifers of such families as Epiphanidae, Synchaetidae, Trichocercidae, Brachionidae, etc. Most of the identified Rotatoria species are plankton and kelp inhabitants of water bodies. Among rare species there is rotifer *Stephanoceros fimbriatus*. The representatives of *Notholca* (indicator of poorly contaminated waters) are quite common. In general, the rotator complex of the Lake Semyonovskoe has much in common with the Lake Ledovoe and the Lake Okunevoe.

The standard representatives of copepods include *Cyclops* sp. and *Diaptomus* sp. Among cladoceran there are many Chidoruses and Daphnias. Seed shrimps (Podocopa order) were found. Among insects there are wiggle-tails of Chironomidae family. The arachnids in the Lake Semyonovskoe are represented by water mites (Hydracarina order).

TABLE 3: Degree of dominance and frequency of hydrobionts occurrence in the Lake Semyonovskoe.

n/n	Taxon	Degree of dominance (Pi), %	Frequency of occurrence (V), %
1	<i>Peridinium</i> sp.	+	12.5
2	<i>Actinosphaerium</i> sp.	+	25.0
3	<i>Coleps cf. hirtus</i>	++	87.5
4	<i>Prorodon</i> sp.	+	12.5
5	<i>Dileptus cf. anser</i>	+	50.0
6	<i>Amphileptus</i> sp.	+	75.0
7	<i>Loxodes cf. rostrum</i>	+	12.5
8	<i>Loxophyllum cf. meleagris</i>	+	12.5
9	<i>Paramecium cf. bursaria</i>	+	50.0
10	<i>P. cf. caudatum</i>	++	50.0
11	<i>Glaucoma</i> sp.	+	37.5
12	<i>Stentor cf. polymorphus</i>	+	25.0
13	<i>S. cf. roeseli</i>	+	12.5
14	<i>Spirostomum</i> sp.	+	62.5
15	<i>Bursaria cf. truncatella</i>	+	25.0
16	<i>Aspidisca</i> sp.	+	50.0

n/n	Taxon	Degree of dominance (Pi), %	Frequency of occurrence (V), %
17	<i>Colpoda</i> sp.	+	12.5
18	<i>Oxytricha</i> sp.	+	87.5
19	<i>Stylonichya</i> cf. <i>mytilus</i>	+	25.0
20	<i>Uroleptus</i> cf. <i>piscis</i>	+	25.0
21	<i>Euplotes</i> sp.	+	25.0
22	<i>Vorticella</i> sp.	++	75.0
23	Stenostomidae	+	25.0
24	Nematoda indet.	+	62.5
25	Gastrotricha indet.	+	50.0
26	<i>Brachionus</i> sp.	+	37.5
27	<i>Notholca</i> sp.	+	12.5
28	<i>Enteroplea</i> cf. <i>lacustris</i>	+	25.0
29	<i>Keratella</i> cf. <i>quadrata</i>	+	87.5
30	<i>Filinia</i> sp.	+	37.5
31	<i>Asplanchna</i> sp.	++	100.0
32	<i>Epiphanes</i> sp.	++	75.0
33	<i>Synchaeta</i> cf. <i>pectinata</i>	++	100.0
34	<i>Rotaria</i> cf. <i>rotatoria</i>	+	37.5
35	<i>Habrotrocha</i> sp.	+	25.0
36	<i>Trichocerca</i> sp.	+	50.0
37	<i>Stephanoceros</i> cf. <i>fimbriatus</i>	+	12.5
38	<i>Tubifex</i> cf. <i>tubifex</i>	+	12.5
39	Lumbriculidae	+	12.5
40	Oligochaeta indet.	+	37.5
41	<i>Chydorus</i> sp.	+	50.0
42	<i>Daphnia</i> sp.	+	37.5
43	<i>Sida</i> sp.	+	25.0
44	Podocopida	+	12.5
45	<i>Cyclops</i> sp.	+	50.0
46	<i>Diaptomus</i> sp.	+	12.5
47	Chironomidae	+	25.0
48	Nemouridae	+	12.5
49	Haliplidae	+	12.5
50	Hydracarina	+	12.5

The saprobity index of the Lake Semyonovskoe makes 1.85 ± 0.16 (β -mesosaprobic waters).

The Lake Semyonovskoe is the most studied urban water object since 2002. Thus, in 2002-2004 the samples included such flag species of clean waters as caddis worms (Goeridae, Phryganeidae, Molannidae), dayflies (Heptageniidae), stoneflies (Nemouridae). Among common whelk, the common representatives of bottom samples were *Lymnaea stagnalis* and *Planorbis planorbis* [11]. These organisms have hardly been detected in recent years of the study.

The species diversity of organisms by years is shown in the figure.

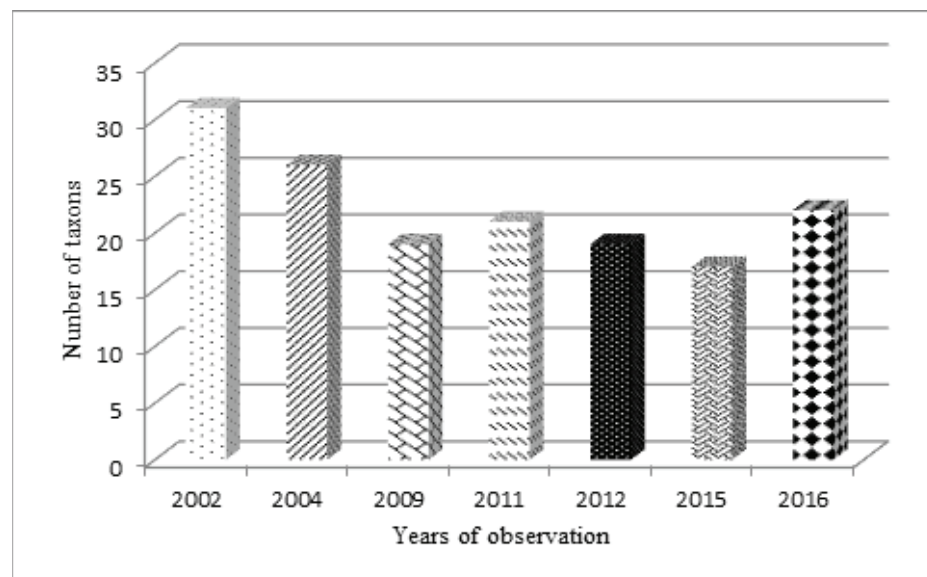


Figure 1: Species diversity in the Lake Semyonovskoe.

In analyzing and comparing the obtained results with previous works it is worth noting the initial signs of anthropogenic eutrophication of the lake. The increase in the number of rotifers from Brachionidae and Trichocercidae families, daphnids (Chidoruses, Daphnias), and some other species can lead to the change of dominant species in aquatic biocenosis of the Lake Semyonovskoe and to the restructuring of the entire community. The Lake Semyonovskoe is characterized by a decreasing tendency of species occurrence -- indicators of clean waters.

4. Discussion

In the Lake Ledovoe, the dominant species represent small organisms with simple life cycles and a high rate of reproduction. There is a prevalence of rotifers of Brachionidae and Filinidae families, shrimps, which is typical for water bodies subject to pollution and anthropogenic eutrophication.

Among infusorias of the Lake Okunevoe there are several dominant species (indicators of alpha- and beta- mesosaprobe waters). The species diversity of the microzooplankton community is higher than in the Lake Ledovoe. There are no organisms -- indicators of clean waters. In general, the Lake Okunevoe can be assessed as a water body with signs of damage to ecosystem stability.

The hydrobiocenosis of the Lake Semyonovskoe is characterized by the greatest species wealth. There is a prevalence of small-sized organisms of predominantly heterotrophic nutrition. There is a decreasing tendency of species composition of organisms -- indicators of clean waters. There are initial signs of anthropogenic eutrophication of the water body.

Seasonal changes are observed in the zooplankton community of lakes. The greatest composition of species wealth and the maximum number and biomass of zooplankton are typical for summer period. The base number of zooplankton of the studied lakes is ensured by eurybionts having a greater ability to adapt to changing environmental conditions [13]. The governing complex of zooplankton communities of the studied lakes constitute the typical representatives of northern fauna. Seasonal differences in the state of zooplankton lakes are clearly determined by structure or ratio of the main taxonomic groups of the community. The structure of the zooplankton community in the seasonal aspect should be taken into account in bioindication of the state of aquatic ecosystems and possible changes in the action of climatic and anthropogenic factors [13, 14].

Macrozoobenthos of the studied lakes is characterized by low taxonomic diversity, which is consistent with the studies carried out on some small lakes of the Kola Peninsula [14, 15].

Despite some differences in species diversity of lakes, there are species present in all water bodies. Among worms in the fauna of water bodies of Murmansk there are several species of turbellarian worms. The roundworms (Nemathelminthes) are represented by free-standing species of nematodes and rotifers. The ringworms (Annelida) are represented by several species of oligochaetes (*Tubifex* sp.) and leeches (Hirudina). The mollusks are represented by several species of common whelks and bivalved mollusks. Among bivalved mollusks, pisidium (Pisidiidae) is the most common in the water bodies of Murmansk. Among arthropods (Arthropoda) there are species of Crustacea and Insecta. The arachnids in fresh waters are represented by a group of aquatic mites commonly named as Hydracarina. The lakes are characterized by the presence of Crustacea belonging to copepod order (Copepoda) --Cyclops (*Cyclops*), cladocerans, or

cladocerans (Cladocera) of the Chydoridae family, less common you can meet the representatives of Daphnia and Bosmina. Among insects there are (Trichoptera), larvae and wiggle-tails of the two-winged order (Diptera). Adult insects or their larvae may dominate in numbers, especially for midges or chironomids (Chironomidae). Infusorias account for 50 to 70% of organisms identified in the samples. The subdominants depending on the sampling season represented roundworms (Nematoda sp. and Rotatoria), oligochaetes and wigglers [11].

5. Conclusion

The results of the saprobity index (S) calculations showed that the waters of the lakes under study were characterized as β -mesosaprobic (moderately contaminated).

In general, it was noted that the fauna of freshwater bodies of Murmansk is characterized by small species diversity. The dominant species represent small organisms with simple life cycles and a high rate of reproduction. There is a prevalence of small-sized organisms of heterotrophic nutrition. There is a tendency of decreasing the species diversity and simplifying trophic connections in aquatic ecosystems subject to anthropogenic impact.

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Conflict of Interest

The authors have no conflict of interest to declare.

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