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ECOLOGICAL AND TAXONOMIC STRUCTURE OF WINTER ALGOCOENOSIS IN THE RIVERS OF THE SEVASTOPOL REGION

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ЭКОЛОГО-ТАКСОНОМИЧЕСКАЯ СТРУКТУРА ЗИМНИХ АЛЬГОЦЕНОЗОВ РЕК СЕВАСТОПОЛЬСКОГО РАЙОНА

Abstract. The paper considers the ecological and taxonomic structure of the winter algocoenosis of the Chernaya, Kacha, and Belbek rivers within the territory of the city of Sevastopol. The results of studies were obtained on 30 chemical and physical parameters of surface water samples during the period of algological sampling. The collection of field material (phytoplankton, algae in fouling, on various substrates immersed in water) and its processing was carried out according to the methods generally accepted in algological practice. The diagnostic features, as well as the similarities and differences in the species diversity of algae, have been determined. The studies carried out show that the studied algocoenosis are characterized in winter period by a rich species composition, with a significant predominance of diatoms. The algae found in the studied rivers are indicators of water purity, and their occurrence activity and abundance can indicate that the content of organic matter in the waters of the Belbek and Kacha rivers is lower than in the Chernaya river. This is confirmed by the presence of algae – xenosaprobionts in the waters of the Belbek and Kacha rivers, which are indicators of clean, not polluted, with organic substances water.

Keywords: Algae, Environmental Conditions, Species, River, Crimea.

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Аннотация. В работе приведены первые результаты эколого-таксономических исследований зимнего альгоценоза рек Черная, Кача и Бельбек в пределах территории города Севастополя. Получены результаты исследований по 30 химико-физическим параметрам проб поверхностной воды в период отбора альгологических проб. Сбор полевого материала (фитопланктон, водоросли в обрастаниях, на различных субстратах, погруженных в воду) и его обработка производился по методикам общепринятым в альгологической практике. Определены диагностические признаки, а также сходства и различия видового разнообразия водорослей. Проведенные исследования показывают, что изученный альгоценоз характеризуется в зимний период богатым видовым составом, со значительным преобладанием диатомовых. По найденным в исследованных реках водорослям – индикаторам чистоты воды, их встречаемости, можно свидетельствовать о том, что содержание органических веществ в водах рек Бельбек и Кача ниже, чем в реке Чёрная. Это подтверждается наличием в водах рек Бельбек и Кача водорослей – ксеносапробионтов, индикаторов чистой, не загрязненной органическими веществами воды.

Ключевые слова: водоросли, экологические условия, вид, река, Крым, сапробность

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Introduction. Within the Sevastopol region, there are three main rivers (the Chernaya river, the Belbek river and the Kacha river), which, according to the classification of Alekin O.A., refer to as small rivers [2].

The Chernaya River is 35 km long, the catchment area is 669 km^2, and the river is one of the most significant in terms of length and water content. The river is fed mixed – atmospheric and underground. When analyzing the average long-term runoff hydrograph, two periods are distinguished: a high-water period (from December through April), when 51.2% of the annual runoff passes, and a low-water period (from May to November).

The Belbek River is the most full-flowing of the Crimean rivers, flows in the southwest of the Crimea. Its length is 55 km, the catchment area is 505 km^2, and the slope of the river is 6.0 m/km. The section of the river from the village Frontovoe to the village Lyubimovka forms a 16 km lower section, the river flows into the Black Sea. The Belbek River is a typical undying mountain river with a high channel current, meandering in the mouth part. The river valley is box-shaped, with a width of up to 2000 m in the studied area.

The length of the Kacha River is 64 km, the catchment area is 573 km^2. In the upper and middle reaches, it is a typical mountain river that flows into the Black Sea to the south of the village Kacha, to the north of the city of Sevastopol. The river's own flow is regulated, two reservoirs were built on the Kacha River: Zagorskoe in 1980, volume – 27.85 million m^3 and Bakhchisarayskoye has been operating since 1935, its volume is 6.89 million m^3, used for water supply to the city of Simferopol and irrigation.

Materials of studies of freshwater algae in the region under study have not been found in literary sources.

Materials and Methods. The purpose of this work is to study the composition of algological communities of river algae in the winter and assess their state.

The studies were carried out at the Department of Ecology of Nizhnevartovsk State University, according to the methods adopted in algology [1; 7; 8]. The material for the work was original samples in the water column (phytoplankton), as well as in fouling, on various substrates, submerged in water in the channel of the Chernaya, Belbek and Kacha rivers. Samples were taken in the first ten days of February 2019 in 4 sections.

Determination of the species composition was carried out on a fixed formalin material, bringing it to 4% concentration. A pHScan WP2 portable water analyzer was used to determine the temperature and acidity of water. The chemical composition of water is determined by 30 indicators (tabl. 1).

Preparation for identification was carried out by sedimentary gravimetric method and the manufacture of permanent preparations by cold burning, subsequent centrifugation, and placing the obtained valves of diatoms in Canadian balsam. Microscopic examination was carried out using light microscopes Nikon ECLIPSE E200 and OLYMPUS SX4 with a multiple magnification from 640 to 2000.

The taxonomic affiliation of algae was established using domestic keys and taking into account nomenclature changes in the international electronic database [11].

Floristic analysis of the composition of algocoenosis of the rivers of the Sevastopol region was carried out using generally accepted indicators: a systematic analysis, the proportions of flora (calculated as the ratio of the number of genera; species; varieties and forms — in 1 family), generic coefficient (generic saturation with species and intraspecific taxa), floristic spectra [10].

When processing samples, the frequency of occurrence of the species was determined using the following symbols: + – very rarely (the species is not present in every preparation); 1 – singly (1-6 copies in the preparation); 2 – few (7-16 specimens in the preparation); 3 – decently (17-30 copies in the preparation); 4 – many (31-50 specimens in the preparation); 5 – a lot, absolute predominance (more than 50 specimens in the preparation) [13].

The ecological and geographical characteristics of algae are given according to guidelines [4; 7; 8; 11].

Results. The water temperature during the research period varied within 3-5°C, the activity of hydrogen ions varied from 7.5 to 8.1. The results of the quantitative chemical analysis of water are substituted in table 1.

Table 1

Results of chemical and analytical studies of surface water samples (February 2019)

Indicator	Kacha river	Belbek river	Belbek river	Chernaya river	Maximum Allowable Concentration
Temperature, °C	5,0	3,0	4,0	4,0	–
pH, units pH	7,5	7,5	7,6	8,1	–
Smell, point	0	0	0	0	–
Colour, degree	<1	<1	<1	<1	–
Transparency, cm	transparent	transparent	transparent	transparent	–
Dissolved oxygen, mg/dm^3	7,3	7,1	8,2	7,8	–
General stiffness, dH	11,8	6,2	6,3	3,7	–
Suspended substances, mg/dm^3	18,5	76,5	10,5	12,5	–
The amount of ions (dry residue), mg/dm^3	357	321	310	287	
Oil products, mg/dm^3	0,013	0,013	0,009	0,007	0,05
BOD_5, mgO_2/dm^3	3,4	2,9	2,3	2,5	2,1
COD, mg/dm^3	6,7	5,7	5	6,8	–
Anionic surfactants, mg/dm^3	<0,1	<0,1	<0,1	<0,1	–
Oxygen saturation percentage, %	57,08	52,63	62,45	59,41	–
Sulfates, mg/dm^3	182,5	46,32	53,21	14,91	100
Chlorides, mg/dm^3	137,2	24,17	21,1	12,57	300
Nitrates, mg/dm^3	21,8	9,62	10,85	1,13	40
Nitrite, mg/dm^3	0,05	0,04	0,05	0,34	0,08
Ammonium ion, mg/dm^3	0,13	0,16	0,11	<0,1	0,5
Carbon dioxide, mg/dm^3	10	<10	<10	<10	–
Phosphates, mg/dm^3	<0,1	<0,1	<0,1	<0,1	–
Hydrocarbonates, mg/dm^3	229	269	223	231	–
Phenols (amount), mg/dm^3	0,0068	0,0175	0,002	0,0072	0,001
Calcium, mg/dm^3	81,52	85,63	24,15	73,64	180
Magnesium, mg/dm^3	23,61	15,52	40,36	8,95	40
The amount of sodium and potassium, mg/dm^3	59,84	22,84	18,16	16,35	–
Total iron, mg/dm^3	0,009	0,008	0,007	0,008	0,1

Indicator	Kacha river	Belbek river	Belbek river	Chernaya river	Maximum Allowable Concentration
Manganese, mg/dm^3	0,004	0,003	0,004	0,002	0,01
Copper, mg/dm^3	0,0013	0,0016	0,0013	0,0015	0,001
Zinc, mg/dm^3	0,005	0,007	0,007	<0,005	0,01
Chromium (VI), mg/dm^3	<0,001	<0,001	<0,001	<0,001	0,02
Nickel, mg/dm^3	<0,002	<0,002	<0,002	<0,002	0,01
Total nitrogen, mg/dm^3	0,57	0,58	0,53	0,55	–
Total phosphorus, mg/dm^3	0,23	0,54	0,24	0,21	–
Silicon, mg/dm^3	<0,5	<0,5	<0,5	<0,5	–
α-HCCH, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
β-HCCH, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
γ-HCCH, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
DDT, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
DDD, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
DDE, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	0,00001
HCB, mg/dm^3	<0,00001	<0,00001	<0,00001	<0,00001	-

As a result of winter studies at four sections of the Chernaya, Belbek and Kacha rivers, 82 species and varieties of algae were identified, included in 5 divisions, 6 classes, 21 families and 44 genera (tabl. 2).

Table 2

Systematic composition of algae in the rivers of the city of Sevastopol

Division	Class	Families	Genera	Number of species, varieties and forms	% of the total number of species (species, varieties and forms)
Cyanobakteria	1	1	1	1	1,2
Chrysophyta	1	1	2	2	2,4
Bacillariophyta	2	16	33	66	80,5
Euglenophyta	1	1	5	9	11,0
Chlorophyta	1	2	3	4	4,9
Total:	6	21	44	82	100

The overwhelming number of algae belongs to diatoms, which is explained by the temperature indicators of the water typical for the winter period.

The Cyanophyceae class is represented by one species, the Chrysophyceae class – two species, Chlorophyceae – 4, Mediophyceae – 5, Euglenophyceae – 9, Bacillariophyceae includes 61 species and varieties.

In the family spectrum, Cymbellaceae is the leader, in which there are 13 species of algae, they make up 15.9% of the total list composition, 5 genera have been found in this family. The second place is occupied by Euglenidae – 9 algae, 11.1%, 5 genera. Gomphonemataceae ranked third with 8 algae, 9.9%, genus 1. The fourth place is Cosmioneidaceae – 7 species, 8.5%, 3 genera. The Naviculaceae family completes the leading spectrum of families, in which 6 algae have been identified, which is 7.3%, this family includes 4 genera. Thus, the dominant five families include 52.4% of all identified algae and 19 genera (43.2% of the total identified generic spectrum). Only 2 representatives were found in seven families, and one in four families. In the rest of the families, from 3 to 5 algae were found.

The generic spectrum is headed by Gomphonema, which includes 8 algae, which is 9.8% of the total algocoenosis of the rivers. The genera Gyrosigma, Amphora and Cymbella contain 4 species each, making up 14.7% in total. Five genera include 3 species each, 12 genera of 2 species each, and 23 genera are single species.

The richest variety of algae is found in the Belbek river, in the Chernaya and Kacha rivers it is almost two times less (tabl. 3).

Table 3

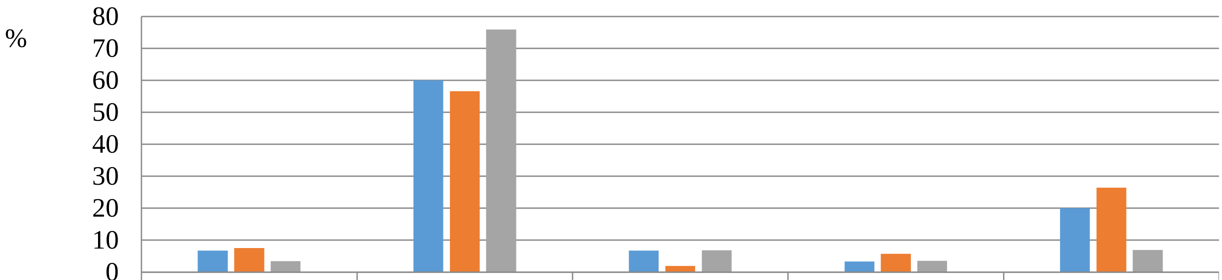
Taxonomic diversity and proportions of flora in individual watercourses of the Sevastopol region

River	Number of				Flora proportions	Generic saturation
	divisions	families	generas	Species and varieties		
Chernaya	3	15	20	30	1:1,3:2,0	1,5
Belbek	5	19	32	53	1:1,7:2,8	1,7
Kacha	3	13	21	29	1:1,6:2,2	1,4
Total	5	21	44	82	1:1,5:2,3	1,6

The highest indicators of the proportions of flora and generic saturation are noted in the waters of the Belbek River, which indicates the richest algological community of the watercourse.

When studying the distribution of the detected algae, depending on the habitat conditions, it was determined that the ecological group of planktonic organisms includes 26 algae, or 32.5% of the list composition, the benthos group (fouling and bottom) includes 40 species, or 48.8%.

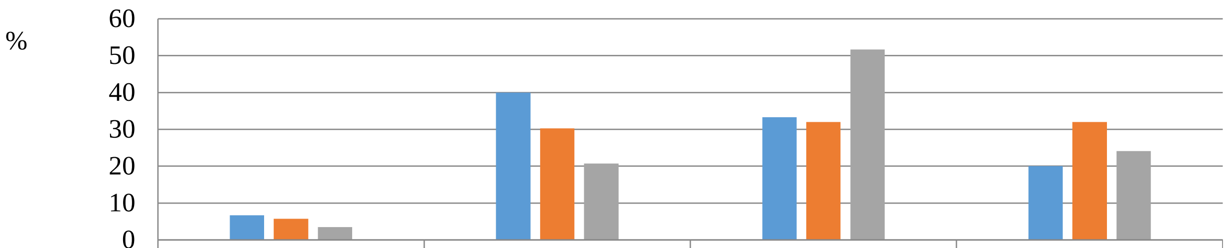
Algae are able to develop equally abundant in a wide range of salinity. It is known that a significant number of them, especially diatoms, are good indicators of the degree of salinity of the aquatic environment. When assessing the ecological plasticity of the freshwater algae of the Chernaya, Belbek and Kacha rivers, depending on the concentration of salts in the water, there were found 24, 39 and 27 indicator species respectively, for which data on water salinity are known. The main part of them was oligohalobes, among which indifferent species prevailed, preferring waters with mineralization of 0.2-0.3 g/l (fig. 1, 2).



	Halophobes	Indifferent	Halophiles	Mesogaloba	Unidentified nature
Chernaya	6,7	60	6,7	3,3	20
Belbek	7,5	56,6	1,9	5,7	26,4
Kacha	3,4	75,9	6,8	3,5	6,9

Fig. 1. Distribution of algae depending on salinity

The most widespread indifferent species in relation to halogenesis were: *Ulnaria acus* (Kützing) Aboal, *U. ulna* (Nitzsch) Compère, *Navicula cryptocephala* Kützing, *N.radiosa* Kützing, *Gyrosigma* strigilis (W.Smith) J.W.Griffin & Henfrey *Planothidium lanceolatum* (Brébisson ex Kützing) Lange- Bertalot, *Cymbella aspera* (Ehrenberg) Cleve, *Cocconema ventricosum* (Kützing) G. S. West, *Amphora ovalis* Kützing, *Nitzschia palea* (Kützing) W. Smith.



	Acidophiles	Indifferent	Alkaliphiles	Unidentified nature
Chernaya	6,7	40	33,3	20
Belbek	5,7	30,3	32	32
Kacha	3,5	20,7	51,7	24,1

Fig. 2. Distribution of algae depending on active water reaction

The share of halophobes growing in waters with salinity up to 0.1 g / l is in the range from 3.4% (Kacha river) to 7.5% (Belbek river). The share of gallophiles in the river Belbek is the smallest (1.9%), in the rivers Kacha and Chernaya it reaches 6.8%. The obtained results characterize the algoceneses of the Sevastopol region in terms of the composition of halogenesis indicators as freshwater with a predominance of indifferent and the participation of halophobic and halophilic algae and mesohalobes.

The pH value is an ecological factor on which the growth and reproduction of algae depends.

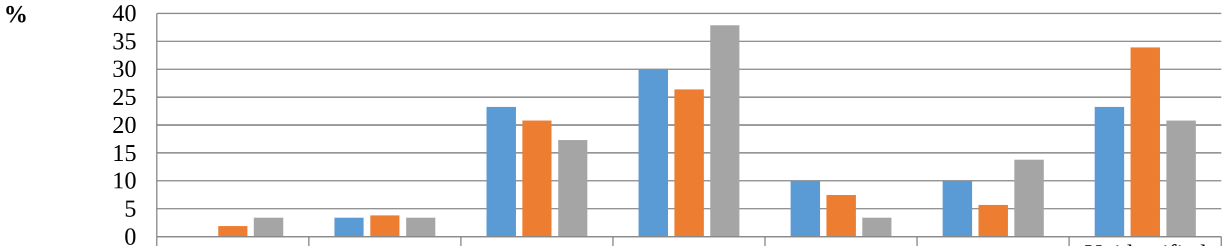
The share of acidophiles in rivers varies from 3.5% (Kacha) to 6.7% (Chernaya). This group is represented by only five diatoms: Meridion circulare (Greville) C. Agardh, Denticula thermalis Kützing, Eunotia faba (Ehrenberg) Grunow, E.minor (Kützing) Grunow, Gomphonema acuminatum Ehrenberger, the occurrence of which did not exceed two points. Thus, for the listed species, the vegetation period is below average.

The fractional participation of alkaliphiles living in alkaline environments and indifferent algae is characterized by high data.

Discussion. Control and monitoring of the levels of surface water pollution in the system of protection and rational use of water resources occupy an important place. In order to determine the quality of surface waters, assess the state of water systems and their changes as a result of anthropogenic influences, hydrobiological observations are carried out, characterizing the quality of water as a habitat for living organisms inhabiting water bodies. Due to the high sensitivity of algae to environmental conditions, they play an important role in the biological analysis of water [5]. Bioindication aspects of algal ecology are the most developed in comparison with other groups of organisms [3].

Bioindication, as a method of water quality control, is considered the most reliable and universal, since for these purposes the most sensitive species of aquatic organisms are used, which adequately respond to changes in environmental factors. The indicators of the degree of saprobity of water in our study were 23 species for the Chernaya river, which is 76.7% of the total number of taxa; for the Belbek river - 35 species, or 66.1%, for the Kacha river – 23 species, or 79.2% (fig. 3).

The most widely represented is the group of mesosaprobes - indicators of the average degree of water pollution by easily oxidizable organic substances actively participating in the self-purification process; the range of the share of this ecological group along the rivers varies from 26.4% (Belbek river) to 37.9% (Kacha river). The occurrence of algae of this group in the water bodies of the Sevastopol basin reached 2-3 points: Ulnaria acus (Kützing) Aboal, U. ulna (Nitzsch) Compère, Cymbella aspera (Ehrenberg) Cleve, Cocconema ventricosum (Kützing) G. S. West.



	χ-o; o-χ	o	o-β; β-o	β	β-α; α-β	α	Unidentified nature
Chernaya	0	3,4	23,3	30	10	10	23,3
Belbek	1,9	3,8	20,8	26,4	7,5	5,7	33,9
Kacha	3,4	3,4	17,3	37,9	3,4	13,8	20,8

Fig. 3. Distribution of saprobiont algae in water bodies:
x –xenosaprobe; o – oligosaprobe; α – α-mesosaprobe; β – β-mesosaprobe

Alfasaprobes testify to the environment in which algae can withstand a significant degree of organic pollution. It should be noted that there is a significant proportion of this group of algae in phytocenoses of rivers: Achnanthes lanceolata var. rostrata Hustedt, Nitzschia palea (Kützing) W. Smith, Hantzschia amphioxys var. virax (Hantzsch) Grunow, Euglena granulata (G.A. Klebs) F. Schmitz, Lepocinclis ovum var. palatina Lemmermann.

Algae-xenosaprobionts — indicators of clean, oxygen-rich water were recorded only in the Belbek and Kacha rivers: Meridion circulare (Greville) C. Agardh.

Conclusion. Thus, in the rivers of the Sevastopol region in the winter period of 2019, a fairly high distribution of algae oligosaprobes and mesosaprobes was noted (from 26.4% to 37.9%). The activity of self-purification processes is confirmed by the fact that they occur at the level of β-mesosaprobic and oligosaprobic waters, when pollutants are bound by their mineralization. The obtained taxonomic composition of algae indicates a stable ecological state of aquatic ecosystems. The positive results of algolization of surface waters are confirmed by the presence of phytoplankton, which was formed during the observation period in 2019. The study is planned to continue during the biological summer.

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