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Natural and anthropogenic influence on biological objects in the Danube mouth area

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ABSTRACT

Problem statement. Recently, throughout the world there has been increased interest in the study of natural objects that occupy a special place on the earth's surface – the estuaries of rivers and their constituent parts – deltas. The estuary area of the Danube, which belongs to the category of specific natural objects and occupies a special place on the European continent, is considered in this study. The modern anthropogenic load on this geographical object requires a scientifically based assessment of its state. One of the assessment indicators proposed is the meiofauna diversity of the estuarine region, which clearly responds to the variability of environmental conditions. The results of this study will contribute to a better understanding of the processes occurring in the coastal zone, which will make it possible to achieve Sustainable Development Goal #14 – Life Below Water, aimed at conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Purpose. The object of research is the river mouth area. The subject is the variability of the characteristics of natural conditions and components of biological populations with the aim of searching and possibly establishing their patterns.

Methods. A systematic approach was chosen as a methodology, which is based on considering an object as a system – a set of interacting objects, associated processes of water dynamics, seasonal season's variability of synoptic processes, the intensity of development of biological objects, etc.

Results. The reaction of biological organisms, using the example of meiobenthos, to anthropogenic impact in areas of dredging, dumping of bottom sediments, background water areas and the natural influence of river flow and seasonal temperature fluctuations is considered. It has been established that meiobenthos indicators experience significant fluctuations in density and biomass not only depending on the location of the study areas, but depend on the season of the year, so in the spring the average density during the study period of meiobenthos was 104897 ± 15243.0 ind./m². In summer, density indicators almost double, averaging 253077 ± 87606.7 ind./m². In autumn they decrease on average to 132155 ± 4837.3 ind./m².

Conclusion. Using the classification of ecological quality (EcoQ), based on the meiobenthic richness (S) variable, the studied water area falls into a status from poor (Poor) in the spring to satisfactory (Moderate) in the summer and autumn. The variability of the studied characteristics (total meiobenthic density) depending on temperature shows the coincidence of a pronounced maximum of meiobenthos development in the summer.

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Introduction

Recently, throughout the world there has been increased interest in the study of specific natural objects that occupy a special place on the earth's surface – the estuaries of rivers and their constituent parts – deltas. The economic use of the rich land, water and biological resources of river mouths is expanding by various sectors of the national economy gravitating towards them. This is, first of all, agriculture (grain farming and the production of vegetable and industrial crops on fertile and deltaic lands, especially in warm climates); river and sea water transport, using the favorable position of river mouths at the intersection of waterways from seas to the interior of continents and vice versa – from rivers to seas, and port construction, fisheries (river mouths are places of spawning, feeding and migration of many valuable species of fish). In addition, river mouths are used by hydropower (construction of tidal power plants), public utilities (water supply to large port and industrial centers and settlements located at river mouths), pulp industry (reed extraction and processing), recreation, tourism, hunting, etc. [1].

At the same time, it is obvious that the modern anthropogenic load on this geographical object requires a scientifically based assessment, conservation and sustainable development from the point of view of the World Heritage ecosystem. One of the criteria proposed is the meiobenthos of the estuarine region, which clearly responds to the variability of environmental conditions. In addition, it is important to clarify at the preliminary stage of research the priority of anthropogenic and natural influences. This thesis is proposed to be highlighted as the purpose of the study. The object of investigation is the branch region of the Danube delta, and the subject of investigation is the daily changes in the characteristics of the medium and components of the biological populations of the branch region of the Danube under the influx of anthropogenic and natural factors.

A specific ecological component of benthic communities is the meiobenthos (meiofauna), which consists of protist and metazoan organisms smaller than 0.5 mm but being retained on a 63 µm mesh [2]. Meiobenthic nematodes are the most diverse and numerically dominant metazoans among-in the marine environment [3-5]. Nematodes due to specific biological characteristics (high productivity, short life cycles) quickly respond to environmental changes by reducing species diversity, increasing abundance and decreasing biomass [6, 7]. Meiobenthos is also able to be the first of the zoobenthos to restore its populations [8-12]. Biological

indicators are considered more significant for assessing environmental quality than with only one physicochemical or abiotic variables [13]. The Water Framework Directive (WFD, 2000/60 / EC) and the Marine Strategy Framework Directive (MSFD, 2008/56 / EC) established the concept of Ecological Quality status (EcoQ) as a way to assess the biological quality of aquatic habitats. EcoQ status is based on the composition of several biological elements and organisms, and among these, meiobenthos and nematode communities may be used as possible tools to determine the EcoQ of the marine sediments [14-20].

The bottom ecosystems of the Odessa Gulf, the Danube coastal zone and with Zhebriyanskaya Bay including, as the part of it, are experiencing strong anthropogenic impacts [21-24].

The formation of meiobenthos in this area can be influenced not only by the large natural variability along the estuarine gradient (for example, the type and dynamics of sediments, the availability of oxygen, temperature and flow rate), but also by anthropogenic impact (for example, dredging and dumping).

Research Methods

To solve the set goals and objectives, the following methods and approaches were used: a systematic approach, a synergetic approach, an expeditionary method and analytical research methods. A systematic approach, which is based on considering an object as a system – a set of interacting objects, associated processes of water dynamics, seasonal synoptic variability, the intensity of development of biological objects, etc. The generalized comprehensive definition of the river mouth area should reflect the location, features of natural conditions and the processes that form them. The environmental conditions and biota in the mouth area of the Danube, where hydraulic engineering work is being carried out at the mouth of the Bistry branch, in particular, dredging and dumping of extracted soil into a designated dumping area, are considered. A station where the environmental characteristics are a priori not subject to anthropogenic impact from hydraulic engineering construction during the current observation period from 2016 to 2021 was selected as background values later, research was not possible. The selection and sorting of data was carried out taking into account the availability of actual measurements and their optimization in general. An assessment of statistical significance was performed. In Figure 1 shows a diagram of the stations whose data were used in the work.

The area is divided into three conditional sites: directly in the sites of dredging (Bystry branch) (depths 3–7 m), dumping (storage of sediment)

(depths 8–13 m) and in water areas remote from dredging and dumping, which can be considered as background where the impact of dredging operations is presumably minimal (depths from 6 to 26 m).

It is impossible to give a comprehensive definition of the river mouth area from the standpoint of any one discipline as a complex geographical complex. To date, the functional role of river mouths in the global process of interaction between land and ocean waters has also been little studied. An analysis of the seasonal dynamics of the taxonomic composition, abundance and biomass of the meiobenthos complex in the research region under the influence of the operation of agricultural agriculture was carried out on material collected in different seasons for the period 2016–2021. A total of 117 meiobenthos samples were processed and analyzed.

For the collection of meiobenthos samples, a Petersen bottom grab with an opening area of 0.25 m² was used. At each station, depending on the type of substrate from the monolith brought by the grab, a quantitative sample was taken with a frame of 10x10 cm with a depth of 5 cm into the ground. Then the meiobenthos sample was washed through a system of benthic sieves with a mesh size of 1 mm, 0.250 mm, 0.100 mm. To capture the meiofauna, a nylon mill sieves with a mesh size of 64 µm was placed on the lower sieve. A clot of suspension with organisms from the sediment was sorted by flotation and transferred to a container, the sample volume

was brought to 100 cm³ with distilled water with the addition of 4% formalin and the “Rosa

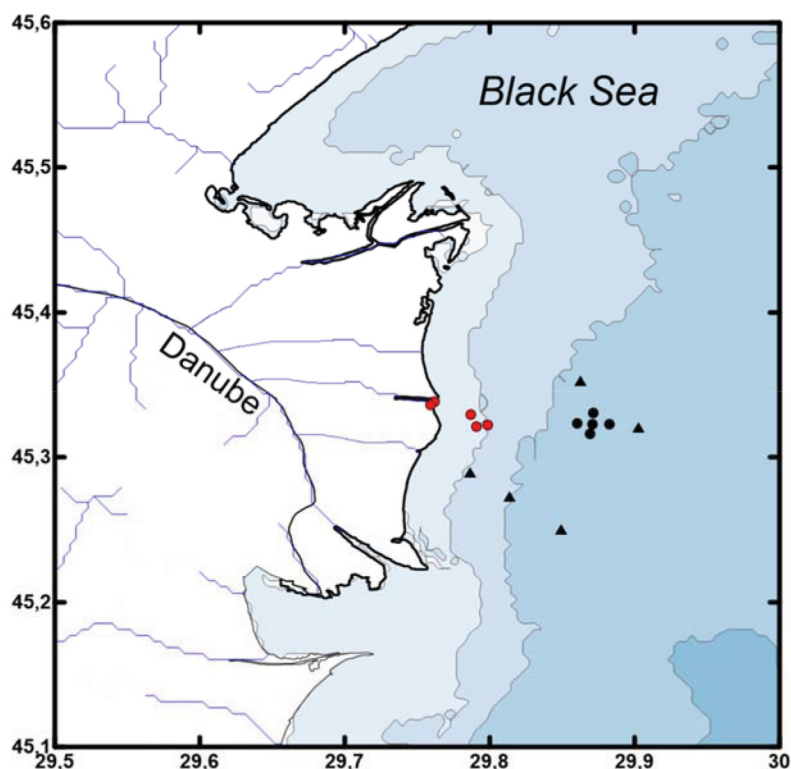


Fig. 1. Scheme of meiobenthos sampling stations in the Danube coastal area (northwestern part of the Black Sea): red circles – dredging stations, black circles – dumping stations, triangles – background stations

Bengal” dye. Under laboratory conditions, the entire sample was viewed under a binocular microscope in Bogorov’s chamber. All groups of meiobenthos were quantified. The number of organisms was recalculated for the entire sample (100 cm³) and for 1 m² of the bottom surface [25]. All groups of meiobenthos were quantified. Each sample contained from several hundred to several thousand meiobenthos organisms, i.e., it was suitable for further systematic processing.

Table 1

Average air temperature and average water runoff in the study area

Month/Year	Air temperature, °C			Water flow values, m ³ /s
	Average	Min	Max	Average
August, 2016	23.8	18.4	27.8	5480
November, 2016	7.2	-1.4	14.7	6230
August, 2017	23.9	16.9	29.4	3680
November, 2017	8.6	4.1	12.6	3680
August, 2018	25.0	23.4	27.5	4860
November, 2018	7.0	-4.3	15.6	3420
May, 2019	19.0	1.8	25.5	8160
August, 2020	24.2	21.4	27.3	4870
May, 2021	16.1	11.9	19.9	7100
October, 2021	12.5	7.6	14.9	3420

Table 2

Seasonal variability of air temperature and water runoff of the Danube

Seasons	Air temperature, °C				Water flow values, m³/s			
	Average	Standard error	Min	Max	Average	Standard error	Min	Max
Spring	17.6	1.5	16.1	19.0	7630	530.0	7100	8160
Summer	24.2	0.3	23.8	25.0	4428	449.2	3680	5480
Autumn	8.8	1.3	7.0	12.5	4188	683.6	3420	6230

The biomass of meiobenthos organisms was determined using the Chislenko nomograms [26].

Discussion Of Results

During the study period, data on air temperature in the estuary coastal area and the Danube runoff were used (Table 1). Seasonal variability data were selected depending on the beginning of the transition period. As the air temperature warmed up, the temperature of the surface layer of water began to increase in spring, decrease in autumn, and start of vertical circulation in winter.

The summer period does not have clearly defined values, since it is characterized by frequent surge fluctuations that affect the temperature. Therefore, it is proposed to consider the summer period from mid-June to mid-September with maximum temperatures in August (Table 2).

We considered the features of the distribution of quantitative characteristics of meiobenthos community in different seasons of the year in the area of construction of the shipping canal and dumping in comparison with the characteristics of small benthic invertebrate animals in water areas, which we consider as “background” and on which the influence of dredging is minimal. The meiobenthic community in the study area is represented by 13 high-ranking taxa: representatives of the permanent component (eumeiobenthos) – *Foraminifera*, *Nematoda*, *Harpacticoida*, *Ostracoda*, *Halacarida*, *Turbellaria*, *Gastrotricha*, *Kinorhyncha* and the temporary component (pseudomeiobenthos) – *Oligochaeta*, *Polychaeta*, juvenile *Bivalvia*, *Gastropoda*, *Balanus*. The number of meiobenthos groups at stations varied from 2 to 8. In different seasons of the year, their number varied from 5 to 11, with their predominance in the summer.

Dredging area. Despite the dredging in the summer, the development of meiobenthos groups is observed, in contrast to the cold periods in spring and autumn. The influence of freshwater runoff variability, in particular its decrease in summer low water in contrast to temperature, is manifested in an increase in the development of meiobenthos groups and a reduction in

meiobenthos groups in spring and autumn, which indicates the general dominance of natural processes of temperature and runoff development over anthropogenic processes, which (dredging) suppress the development of meiobenthos community (Fig. 2).

Five meiofaunal taxa (*Nematoda*, *Harpacticoida*, *Polychaeta*, *Oligochaeta* and *Bivalvia*) were found in the study area during spring. They dominated in density – *Nematoda*, made up 63% of the total meiobenthos, *Harpacticoida* (24.0%), as well as *Polychaeta* (14.0%), *Oligochaeta* made up only 1.0%. In terms of numbers, its permanent component (eumeiobenthos) significantly prevailed in the total meiobenthos, amounting to 87.0% of the total meiobenthos density (average density – 39963 ± 32863.0 ind./m²; average biomass – 180.9 ± 126 mg/m²) (Fig. 3).

In the summer, in the dredging area, an increase in the number of meiobenthos groups to seven was noted: *Nematoda*, *Harpacticoida*, *Ostracoda*, *Oligochaeta*, *Polychaeta*, *Bivalvia*, *Balanus*. However, the quantitative indicators of eumeiobenthos remained at the same level as in the spring, amounting to 91.0% of the total meiobenthos density (average density – 37531 ± 17165.4 ind./m²; average biomass – 171.7 ± 62.4 mg/m²). *Nematoda* dominated in density, 65% of the total meiobenthos, *Harpacticoida* accounted for 25.0%. The density of *Polychaeta* was (4.0%). Pseudomeiobenthos accounted for 13.0% of the total meiobenthos density (average density – 3663 ± 1054.3 ind./m²; average biomass – 157.0 ± 40.5 mg/m²). In the autumn period, the number of meiofauna taxa will increase to eight, among them: *Foraminifera*, *Nematoda*, *Harpacticoida*, *Halacarida*, *Gastrotricha*, *Oligochaeta*, *Polychaeta* and *Bivalvia* were found in the study area. The density of *Nematoda* decreased to 22% of the total meiobenthos, *Harpacticoida* accounted for 27.0%, while the density of *Polychaeta* increased (26.0%), *Oligochaeta* accounted for 15.0%. Quantitative indicators of eumeiobenthos decreased significantly, amounting to 53.0% of the total meiobenthos density (average density – 5769 ± 2068.2 ind./m²; average biomass – 40.7 ± 24.6

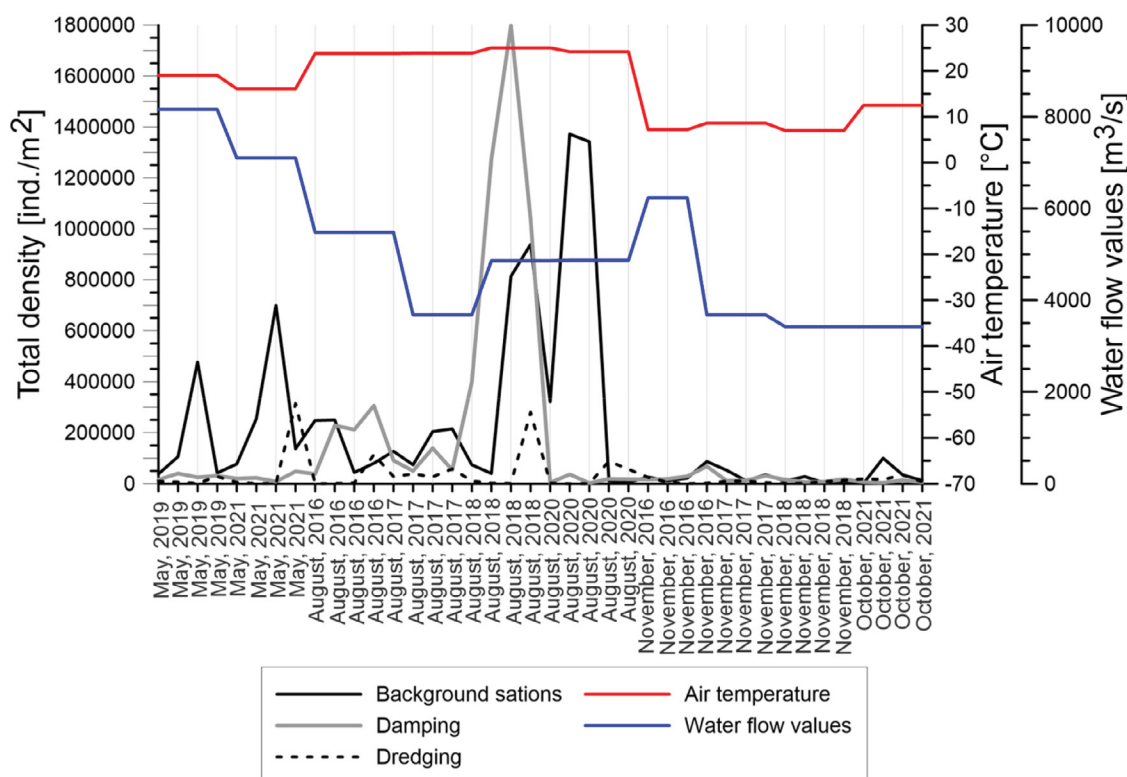


Fig. 2. The influence of environmental variability on the density (ind./m²) of meiobenthos on the Danube delta coastal area

mg/m²). Pseudomeobenthos accounted for 47.0% of the total meiobenthos density (average density – 5215 ± 1733.4 ind./m²; average biomass – 327.5 ± 115.5 mg/m²).

Dumping area. From Figure 2 follows the dominance of the temperature component over the salinity component (Danube water runoff) in the dumping zone during the development of biological processes. At the same time, almost complete restoration of the benthic fauna often occurs, which confirms the feasibility of the alternate filling of the recommended sectors in the dumping proposed by the project developers.

Five meiofaunal taxa (*Nematoda*, *Harpacticoida*, *Turbellaria*, *Oligochaeta* and *Polychaeta*) were found in the study area during spring. In terms of numbers, its permanent component (eumeiobenthos) also significantly

predominated in the general meiobenthos, amounting to 85.0% of the total meiobenthos density, but its quantitative indicators remained low, as in the dredging zone (average density – 22600 ± 4167.6 ind./m²; average biomass – 138.7 ± 48.2 mg/m²). The basis of the quantitative indicators of the entire meiobenthos were *Nematoda* (53%) and *Harpacticoida* (32%). Pseudomeobenthos accounted for 15.0% of the total meiobenthos density. (average density – 3888 ± 1665.3 ind./m²; average biomass – 334.8 ± 100.5 mg/m²). Among the temporary component, Polychaeta dominated in density from the total amount of meiobenthos (14.0%), Oligochaeta made up only 1.0% (Fig. 4).

In the summer, in the dumping area, an increase in the number of meiobenthos groups to eleven was noted: *Foraminifera*, *Nematoda*, *Harpacticoida*,

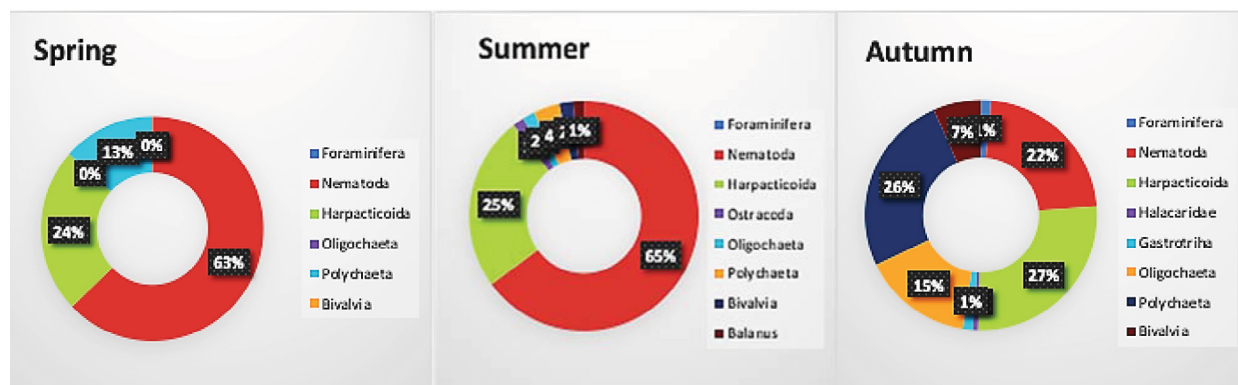


Fig. 3. Frequency (%) of average group density from the total meiobenthos density in the dredging area

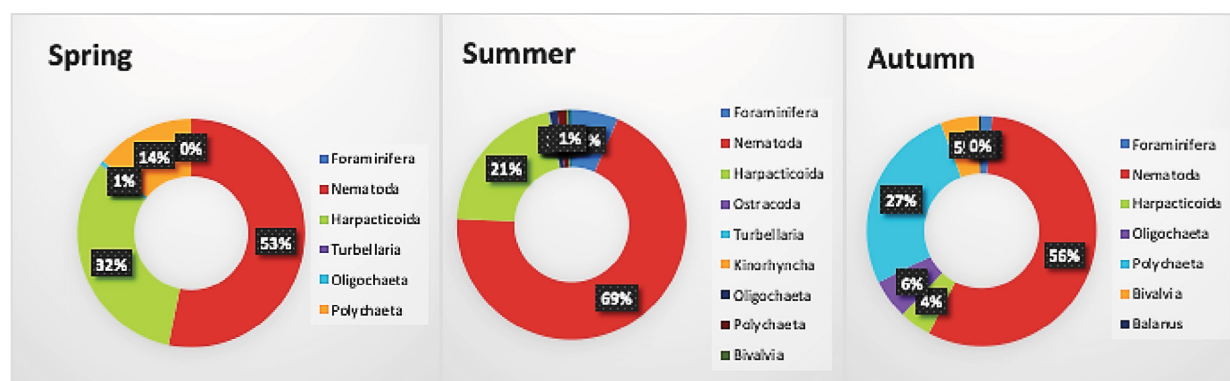


Fig. 4. Frequency (%) of average group density from the total meiobenthos density in the dumping area

Ostracoda, *Turbellaria*, *Kinorhyncha*, *Oligochaeta*, *Polychaeta*, *Bivalvia*, *Gastropoda*, *Balanus*. Quantitative indicators of meiobenthos were an order of magnitude higher compared to spring. In terms of numbers, the meiobenthos was also significantly dominated by its permanent component (eumeiobenthos), amounting to 97.0% of the total meiobenthos density (average density – 355581 ± 133814.2 ind./m²; average biomass – 1825.1 ± 913.1 mg/m²). Nematoda dominated in density, accounting for 69% of the total meiobenthos, Harpacticoida – 25.0%. In the dumping area in the summer, as mentioned above, foraminifera, ostracods, turbellaria and gastrotrichs were recorded, but their quantitative indicators were insignificant. Pseudomeiobenthos accounted for 3.0% of the total meiobenthos density and their indicators were not high compared to such eumeiobenthos, but higher than in the spring (average density – 11050 ± 2903.2 ind./m²; average biomass – 552.4 mg/m²).

During the autumn dumping period, the number of meiofauna taxa decreases to seven, among them: Foraminifera, Nematoda, Harpacticoida, Oligochaeta, Polychaeta, Bivalvia and Balanus. The quantitative characteristics of the entire meiobenthos were low. As noted above, in the dredging area and at the dumping, there is a decrease in the share of eumeiobenthos in the total meiobenthos density and an increase in

the share of pseudomeiobenthos representatives in the autumn period. Thus, the average density of eumeiobenthos decreased significantly, amounting to 62.0% of the total meiobenthos density (average density – 11067 ± 2068.2 ind./m²; average biomass – 17.1 ± 7.7 mg/m²).

Pseudomeiobenthos accounted for 38% of the total meiobenthos density (average density – 6767 ± 902.5 ind./m²; average biomass – 343.4 ± 50.9 mg/m²). *Polychaeta* dominated in numbers from all meiobenthos (27%), *Oligochaeta* made up 6.0%. *Bivalvia* – 5%.

Background stations. From Figure 2 also follows the dominance of the temperature component over the salinity component (Danube water runoff) in the dumping zone during the development of biological processes. At the same time, almost complete restoration of the benthic fauna often occurs, which confirms the feasibility of the alternate filling of the recommended sectors in the dumping proposed by the project developers.

Eight meiofaunal taxa: *Nematoda*, *Harpacticoida*, *Turbellaria*, *Kinorhyncha*, *Oligochaeta*, *Polychaeta*, *Bivalvia* and *Balanus* were found in the study area during spring. The quantitative indicators of meiobenthos in this zone, in comparison with other study areas (dredging and dumping zones), were high. In terms of numbers, the meiobenthic community was also significantly dominated by its permanent

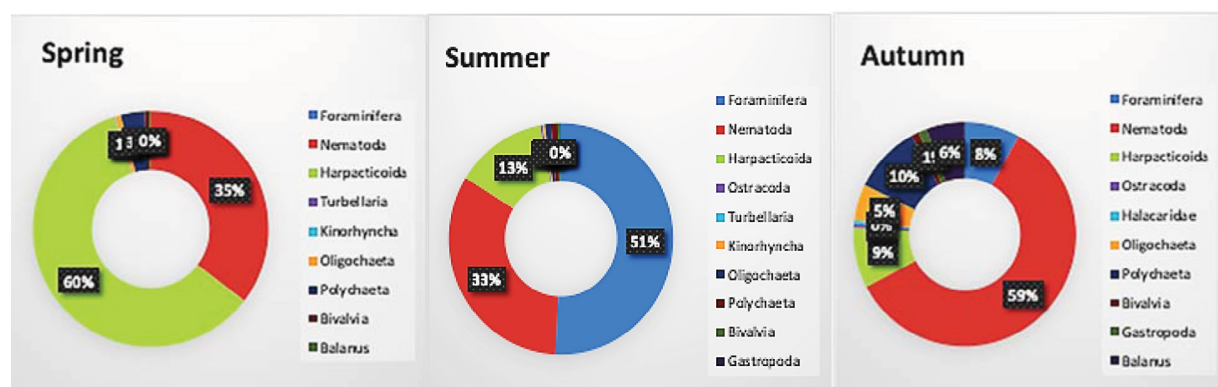


Fig. 5. Frequency (%) of average group density from the total meiobenthos density in the Background stations

component (eumeiobenthos), amounting to 95.0% of the total meiobenthos density (average density – 230071 ± 95643.5 ind./m²; average biomass – 2323.8 ± 1443.8 mg/m²). The basis for the quantitative indicators of all meiobenthos were *Harpacticoida* (60%) and *Nematoda* (35%) (Fig. 5).

Pseudomeiobenthos accounted for 5.0% of the total meiobenthos density (average density – 11957 ± 4166 , ind./m²; average biomass – 674.4 ± 253.6 mg/m²). Among the temporary component, *Polychaeta* (3.0%) dominated in density from the total amount of meiobenthos; *Oligochaeta* made up only 1.0%.

In summer, at background stations, an increase in the number of meiobenthos groups to eleven was noted: *Foraminifera*, *Nematoda*, *Harpacticoida*, *Ostracoda*, *Turbellaria*, *Kinorhyncha*, *Oligochaeta*, *Polychaeta*, *Bivalvia*, *Gastropoda*, *Balanus*. In terms of numbers, its permanent component (eumeiobenthos) also significantly predominated in the total meiobenthos, amounting to 98.0% of the total meiobenthos density (average density – 354169 ± 110057.7 ind./m²; average biomass – 899.2 ± 381.9 mg/m²). Dominant in density of the total amount of meiobenthos were *Foraminifera* (51%), *Nematoda* (33%), *Harpacticoida* (13%). Pseudomeiobenthos made up 3.0% of the total meiobenthos density and their indicators were not high compared to those of eumeiobenthos, and less by an order of magnitude than in the spring (average density ind./m² 8288 ± 2562.1 ind./m²; average biomass – 445.5 ± 126.9 mg/m²).

In the autumn period, the following meiofauna taxa were recorded at the background stations: *Foraminifera*, *Nematoda*, *Harpacticoida*, *Ostracoda*, *Halacarida*, *Oligochaeta*, *Polychaeta*, *Bivalvia*, *Gastropoda*, *Balanus*. A decrease in the proportion of eumeiobenthos in the total density

of meiobenthos and an increase in the proportion of pseudomeiobenthos representatives in the autumn period were noted. The quantitative indicators of the entire meiobenthos were low and significantly lower compared to those in the summer. Thus, the average density of eumeiobenthos was 77.0% of the total meiobenthos density (average density – 23067 ± 6927.6 ind./m²; average biomass – 60.8 ± 10.0 mg/m²). *Nematoda* dominated in density from the total number of meiobenthos, amounting to 59%, *Harpacticoida* (9.0%), *Foraminifera* (8.0%). Pseudomeiobenthos constituted 33% of the total meiobenthos density (average density – 6833 ± 1451 ind./m²; average biomass – 368.7 ± 74.5 mg/m²). The most abundant species of the total meiobenthos were *Polychaeta* (10%), *Bivalvia* – 6%, and *Oligochaeta* – 5.0%.

The heterogeneity of benthic conditions in this area is evidenced by the indicators of density and biomass of meiobenthos representatives, which varied greatly in the study areas under the influence of the marine shipping way operation to the Danube in different seasons in the period 2016-2021. A comparative analysis of the quantitative indicators of meiobenthos in the study area showed their minimum average values in the zone of construction of the shipping canal (dredging zone) and an increase at the dumping and especially at background stations (Fig. 6).

The average density of meiobenthos varied from 10167 ± 2208.2 ind./m² in the autumn period of 2017. (min – 1000 ind./m², max – 28000 ind./m²) to 576583 ± 156727.7 ind./m² in the summer of 2018 (min – 2000 ind./m² and max – 1798000 ind./m²). Average biomass indicators varied from 277.2 ± 59.0 mg/m² in the autumn period of 2017. (min – 0.2 mg/m², max – 629.8 mg/m²) to 2931.9 ± 1183.0 mg/m² (min – 0.4 mg/m², max – 15068.9 mg/m²).

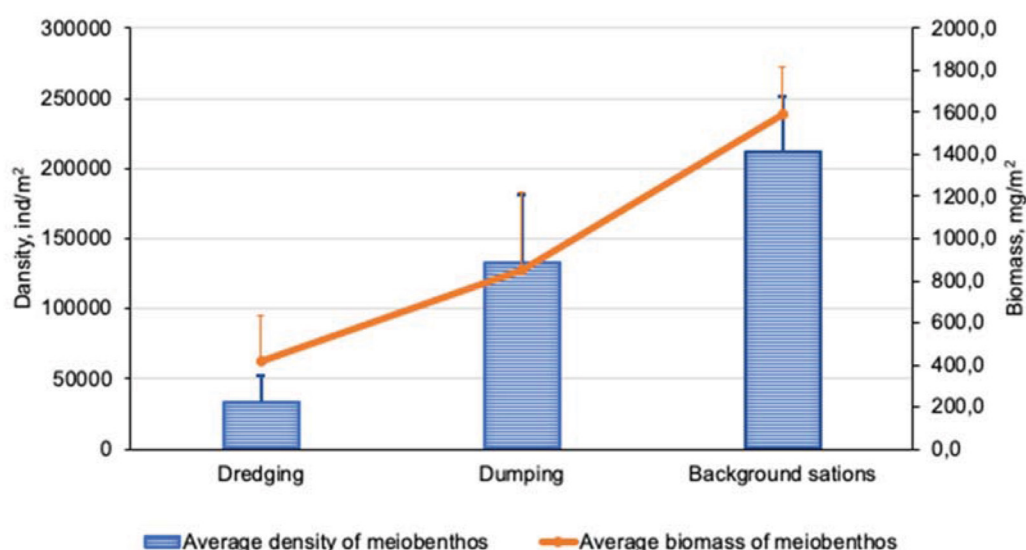


Fig. 6. Average density (ind./m²) and average biomass (mg/m²) of meiobenthos in the areas of the shipping way from the Black Sea to the Danube.

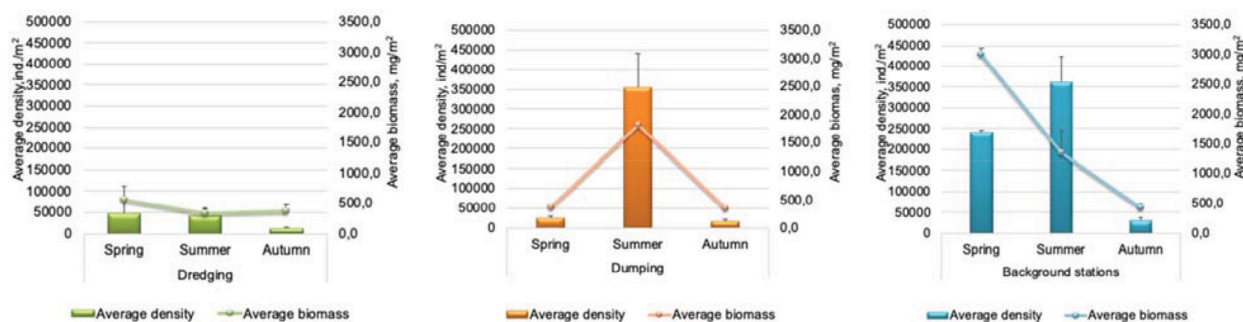


Fig. 7. Average density (ind./m²) and average biomass (mg/m²) of meiobenthos in the study areas at different seasons

In the dredging zone, the lowest average density of meiobenthos is recorded: from 46175 ± 38385.5 ind./m² in spring and 41194 ± 18082.4 ind./m² in summer to an almost threefold decrease in autumn at 10985 ± 2810.4 ind./m². In the dumping zone, the highest indicators of the average density of meiobenthos depended in the summer period on 355581 ± 133814.9 ind./m², in the spring and autumn periods its indicators were only 26488 ± 4533.0 ind./m² and 17833 ± 4134.5 ind./m², respectively. At background stations, the highest average density values are recorded in the spring, amounting to 242029 ± 2810.4 ind./m², and especially in the summer (362457 ± 110923.1 ind./m²) (Fig. 7).

In autumn, the average density of meiobenthos was recorded an order of magnitude lower than previous seasons (29900 ± 7567.0 ind./m²). In spring, the average density of meiobenthos during the study period was 104897 ± 15243.0 ind./m². In summer, density indicators almost double, averaging 253077 ± 87606.7 ind./m². In autumn they decrease on average to 132155 ± 4837.3 ind./m².

The quantitative and qualitative indicators of meiofauna in the Danube region are heterogeneous and depend on various hydrological factors (biotope structure, depth, oxygen). The water flow of the Danube also plays an important role. It is interesting to note that in low-water runoff years in the study area, an increase in the quantitative indicators of meiobenthos is observed compared to high-water years. Figure 8 shows that dependence

of the maximum quantitative indicators of the meiobenthic community on freshwater runoff also persists for the spring – summer period. It is important to note that for the Danube the flood period is quite extended from April to July.

It is confirm the fact that the variability of salt and hydrological regimes leads to the fact that only organisms with great ecological plasticity can exist under these conditions. The zone of mixing of fresh and sea waters, which is characterized by a “minimum of species,” in high-water years along the Danube flow shifts from the coast towards the sea, and in low-water years, on the contrary, this zone passes closer to the mouths, capturing some bays. The more stable the salt composition and the less influence of the Danube waters, the richer and more diverse the meiofauna.

Research has shown that complex changes are continuously occurring in the meiobenthic community, mainly related to seasonal temperature fluctuations. These fluctuations, according to [3], are predetermined by the seasonal cycles of reproduction of meiobenthic organisms. In addition, some authors indicate that seasonal changes in meiobenthic population density largely depend on seasonal changes in food distribution. Typically, high quantitative characteristics of meiobenthos are associated with the period of the year when there are optimal food sources and they are sufficient [27]. The structure of meiobenthos composition is greatly influenced by unforeseen (random) seasonal

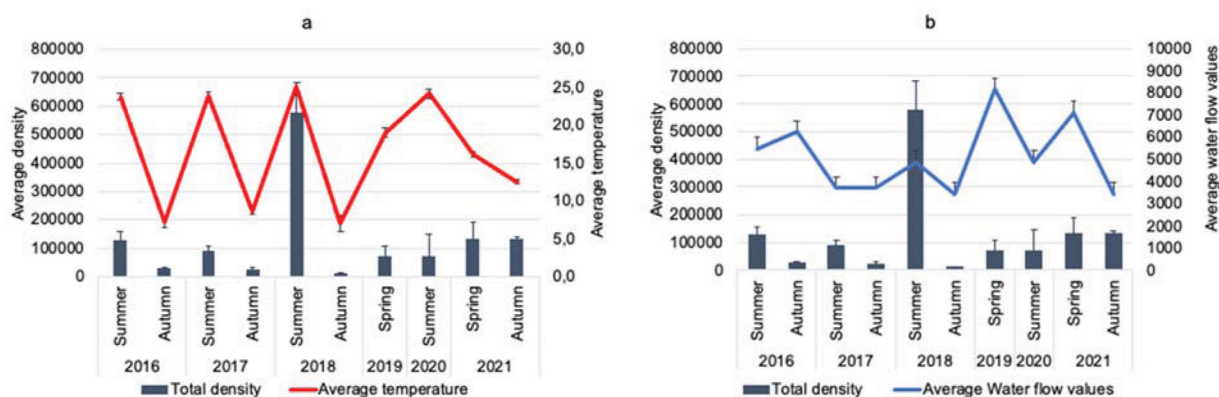


Fig. 8. Dependence of the total density (ind./m²) of meiobenthos community on environmental conditions: (a) – air temperature, °C; (b) – water flow values, m³/s

Table 3

Thresholds of considered to evaluate the EcoQ of the study area according to Danovaro et al. [32]

Faunal parameters	High	Good	Moderate	Poor	Bad
Meiobenthic richness (S)	≥ 16	$16 < S \leq 12$	$8 < S \leq 11$	$4 < S \leq 7$	≤ 4

Table 4

Meiobenthic richness (S), calculated for different areas of the Danube estuary coastal zone in different periods of the year

Season	Spring	Summer	Autumn
Faunal parameters	Meiobenthic richness (S)		
Dredging	4	7	8
Dumping	5	11	7
Background stations	8	11	10

changes in environmental factors [28-30]. Also, the formation of meiobenthos in this area may be influenced not only by large natural variability along the estuarine gradient (e.g. sediment type and dynamics, oxygen availability, temperature and flow speed), but also by anthropogenic influences (e.g. dredging, soil dumping) [31].

The Water Framework Directive (WFD, 2000/60/EC) established the concept of environmental quality status (EcoQ) as a way of assessing the biological quality of aquatic environments. We attempted to assess the ecological status (EcoQ) of the study area based on the number (richness) of meiobenthic taxa, as proposed by Danovaro *et al.* [32], modified according to the WFD classes (Table 3).

In our studies, meiobenthos was characterized by 13 taxonomic groups. The value of meiobenthic richness (S) varied from 4 taxa in the dredging area to 11 taxa at the dumping and background stations (Table 4).

Using the classification of ecological quality (EcoQ), based on the variable meiobenthic richness (S), the studied water area falls into a status from poor (Poor) in the spring to moderate (Moderate) in the summer and autumn.

At the same time, almost complete restoration of the benthic fauna often occurs, which confirms the feasibility of the alternate filling of the recommended sectors in the dumping proposed by the project developers.

Conclusions

The variability of the studied characteristics (total meiobenthos density) depending on temperature shows the coincidence of a pronounced maximum of meiobenthos development in the summer.

The dependence of the maximum meiobenthos abundance on freshwater flow also persists for the spring-summer period. At the same time, almost complete restoration of the benthic fauna often occurs, which confirms the feasibility of the alternate filling of the recommended sectors in the dumping proposed by the project developers.

Using the classification of ecological quality (EcoQ), based on the meiobenthic richness variable (S), the studied water area falls into a status from poor (Poor) in the spring to moderate (Moderate) in the summer and autumn.

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Природний та антропогенний вплив на біологічні об'єкти в гирловій області Дунаю

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АНОТАЦІЯ

Останнім часом спостерігається підвищений інтерес до вивчення природних об'єктів, що займають особливе місце на земній поверхні – гирл річок та їх складових частин – дельт. В дослідженні розглядається естуарний район Дунаю, який належить до категорії специфічних природних об'єктів та займає особливе місце на Європейському континенті. Сучасне антропогенне навантаження на цей географічний об'єкт вимагає науково обґрунтованої оцінки його стану. Одним із запропонованих показників оцінки є різноманітність мейофауни естуарного регіону, яка чітко реагує на мінливість умов навколишнього середовища. Результати дослідження сприятимуть кращому розумінню процесів, які відбуваються в прибережній зоні, що дозволить досягти Цілі сталого розвитку №14 – Життя під водою, спрямованої на збереження та стале використання океанів, морів та морських ресурсів для сталого розвитку. Об'єктом дослідження є гирлова область річки. Предметом – мінливість показників природних умов та компонентів біологічних популяцій з метою пошуку та можливого встановлення їх закономірностей. Як методику було обрано системний підхід, основу якого розгляд об'єкта як системи – сукупності взаємодіючих об'єктів, пов'язаних процеси динаміки вод, сезонна синоптична мінливість, інтенсивність розвитку біологічних об'єктів та інших. Розглянуто реакцію біологічних організмів на прикладі мейобентосу на антропогенну дію в зонах днопоглиблення, дампінгу ґрунту, фонових акваторій та природний вплив стоку річки та сезонних коливань температури. Встановлено, що показники мейобентосу зазнають значних коливань щільності та біомаси не тільки залежно від місця районів досліджень, але залежать від сезону року, тому навесні середня щільність за період дослідження мейобентосу склала $104897 \pm 15243,0$ екз./м². Влітку показники щільності зростають майже вдвічі, склавши загалом $253077 \pm 87606,7$ екз./м². Восени вони знижуються в середньому до $132155 \pm 4837,3$ екз./м². Використовуючи класифікацію екологічної якості (EcoQ), засновану на змінній мейобентосу (Meiobenthic richness, S), досліджувана акваторія потрапляє в статус від бідного (Poor) у весняний період року до задовільного (Moderate) в літній і осінній періоди. Залежно від температури показує збіг яскраво вираженого максимуму розвитку мейобентосу у літній період.

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