ASSESSMENT OF THE ECOLOGICAL STATE OF THE DANUBE DELTA COASTAL AREA (NORTHWESTERN PART OF THE BLACK SEA) BASED ON MEIOBENTHOS AND NEMATODE ASSEMBLAGES

Irina KULAKOVA

Institute of Marine Biology NAS of Ukraine, 37 Pushkinskaya St., 65048 Odessa, Ukraine
e-mail: irakulakoff@gmail.com

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Abstract. The suitability of using meiobenthic communities and especially the nematodes-based indices to assess the ecological quality of the Ukrainian Danube delta coastal area was tested in one control and two sites impacted by dredging/dumping activities. The study is based on the results of benthic surveys carried out in November 2015 and August 2018 and 2020 in the area of the "Danube-Black Sea" navigable canal. The values of the taxonomic richness of the meiobenthos varied from 6 taxa in the dredging sites to 9 taxa at background stations. According to the species richness, the ecological quality in the dredging area fell into the Poor class (EQS), while the background and dumping areas into the Moderate class.

TThe Shannon index (H') of the nematodes in the dredging sites varied from 0 to 1.8. Low values of these indices indicate Bad ecological status in the dredging sites and Poor in the rest. There was a high percentage of c-p2 (r-strategists) in all sites. Average values of the maturity index (MI) varied from 1.5 $\pm$ 0.2 in the dredging sites to 2.3 $\pm$ 0.1 at dumping and 2.6 $\pm$ 0.1 at background stations. The Maturity Index also indicates that the dredging site is in Bad condition, the dumping one is in Poor and the background stations are in Moderate.

Non-selective deposit feeders (1B) dominated at most stations. According to the values of the trophic diversity index (ITD), the study area can be classified as Poor. For the study sites, species that can be considered potential biological indicators are evinced.

Key words: meiobenthos, nematodes, ecological quality status, Danube delta coastal area (Black Sea)

1. INTRODUCTION

Meiobenthic nematodes are the most diverse and numerically dominant metazoans among-in the marine environment (McIntyre, 1969; Heip *et al.*, 1982; De Ley and Blaxter 2001). 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. (Lambshead *et al.*, 1983; Warwick and Clarke 1994). Meiobenthos is also able to be the first of the zoobenthos to restore its populations (Heip *et al.,* 1985; Coull and Chandler 1992; Danovaro *et al.*, 2008; Moreno *et al.*, 2008; 2011). Biological indicators are considered more significant for assessing environmental quality than based on one physicochemical or more abiotic variables (Semprucci and Balsamo 2012). 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 (Balsamo *et al.*, 2010; Höss *et al.*, 2011; Semprucci *et al.*, 2015a, b).

The northwestern part of the Black Sea (NWBS) offers good opportunities for studying meiobenthos and its main representatives under conditions of eutrophication, functioning of ports, and hydro-construction. The underwater biotopes of the Odessa Gulf, and the Danube coastal zone including Zhebriyanskaya Bay, as a part of it, are experiencing strong anthropogenic impacts (Garkavaya *et al.*, 1998; Berlinsky *et al.*, 2005).

In the northwestern part of the Black Sea, free-living nematodes are one of the dominant groups of meiobenthos. In the works (Kulakova, Kulakova and Vorobyova, 2019; Vorobyova and Kulakova, 2009; Vorobyova *et al.* 2016) the analysis of the state of free-living nematodes, a significant component of meiobenthos of the Odessa Bay, Zhebriyanskaya Bay and other areas of the NWBS is given.

The study of the ecological and taxonomic diversity and features of the quantitative development of free-living nematodes on the Danube coast, which is characterized by a high degree of eutrophication in comparison with other areas of the Black Sea, is of great actuality. 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).

The purpose of this study is to provide an assessment of the ecological state of direct anthropogenic load during dredging at the coastal area of the Ukrainian Danube delta, using meiobenthos and nematodes as biological indicators of environmental quality.

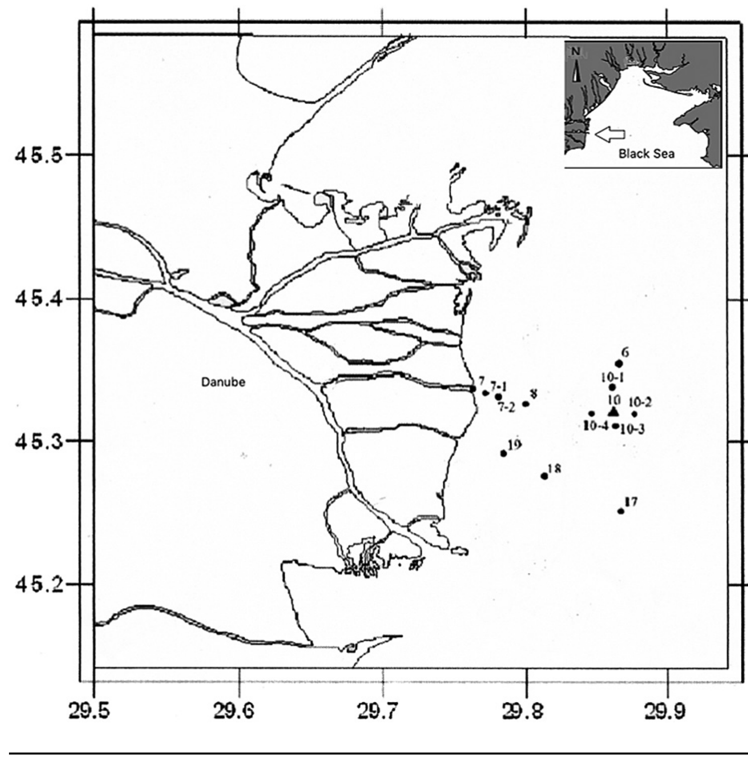

Fig. 1. Geographical location of the stations on the Danube delta coastal area (Northwestern part of the Black Sea).

2. MATERIAL AND METHODS

Study area and sampling sites

The coast area of the Danube delta is a zone of constant interaction between the river and sea waters, as a result of which their properties change. The salinity of the near-bottom water layer at the seaside varies from 13.8 to 18.0 ‰. In the process of mixing in the estuarine zones, 50 to 90% of the solid river runoff is deposited. The hydrodynamic features of the water area affect the dynamics of sedimentation and, as a consequence, the processes of accumulation of various compounds, both biogenic and pollutants, in bottom sediments. Generally, in the near-bottom horizon of the seaside waters, there is an accumulation of organic substances of allochthonous and autochthonous nature, contributing to a sharp decrease of dissolved oxygen (the minimum O_2 values of 2.2 mg / l are observed in the summer period). At the sea surface, salinity mainly depends on the intensity of river runoff and varies in the range of 5.4 – 17.5 ‰. Concentrations of oxygen in the bottom layer vary widely from 0 to 1.4 – 13.9 mg / l. The Danube coast belongs to the hypertrophic regions of the NWBS (Garkavaya *et al.*, 1998; Berlinsky *et al.*, 2005; Berlinsky, 2012).

This study is based on the results of benthic surveys carried out in November 2015, August 2018 and Augus 2020 in the area of the "Danube-Black Sea" navigable canal (Fig. 1).

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). A total of 36 meiobenthos samples were processed and analyzed (Table 1).

For the collection of meiobenthos samples, a Petersen bottom grab with an opening area of 0.25 m^2 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, and 0.10 mm. To capture the meiofauna, a nylon mill sieve 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, transferred to a container, and the sample volume was adjusted to 100 cm^3 with a 4% formalin filtered seawater solution.

Table 1. Sampling details from each station on the Danube delta coastal area (Northwestern part of the Black Sea)

Station	Station code	Date	Depth (m)	Salinity (‰)	Latitude	Longitude	Locality
7	A7	11/2015	7.6	0.2	45°20′31″	29°45′71″	dredging
7-1	A7-1	11/2015	5	0.2	45°20′17″	29°45′57″	dredging
7-2	A7-2	11/2015	6	16.2	45°19′75″	29°47′22″	dredging
8	A8	11/2015	8.5	16.7	45°19′33″	29°47′92″	dredging
10	A10	11/2015	19.5	17.7	45°19′38″	29°52′26″	dumping
10-2	A10-2	11/2015	23.2	17.3	45°19′37″	29°52′95″	dumping
10-3	A10-3	11/ 2015	18.5	17.6	45°18′96″	29°52′17″	dumping
10- 4	A10- 4	11/2015	17.5	17.4	45°19′41″	29°51′63″	dumping
6	A6	11/2015	21.3	17.7	45°19′84″	29°52′27″	background
17	A17	11/2015	25	16.9	45°15′01″	29°50′95″	background
18	A18	11/ 2015	18,7	17.6	45°16′36″	29°48′81″	background
19	A19	11/ 2015	10	16.7	45°17′38″	29°47′17″	background
7	B7	08/2016	7	0.3	45°20′31″	29°45′71″	dredging
7-1	B7-1	08/2016	5.4	0.2	45°20′17″	29°45′57″	dredging
7-2	B7-2	08/2016	5.5	15.9	45°19′75″	29°47′22″	dredging
8	B8	08/2016	9.3	13.5	45°19′33″	29°47′92″	dredging
10	B10	08/2016	19.4	16.6	45°19′38″	29°52′26″	dumping
10-2	B10-2	08/2016	22.4	17.1	45°19′37″	29°52′95″	dumping
10-3	B10-3	08/2016	18,5	17.2	45°18′96″	29°52′17″	dumping
10- 4	B10- 4	08/2016	19	17.1	45°19′41″	29°51′63″	dumping
6	B6	08/2016	21	17.1	45°19′84″	29°52′27″	background
17	B17	08/2016	24.6	17.3	45°15′01″	29°50′95″	background
18	B18	08/2016	18.5	17.2	45°16′36″	29°48′81″	background
19	B19	08/2016	10	14.9	45°17′38″	29°47′17″	background
7	C7	08/2020	6.5	0.5	45°20′31″	29°45′71″	dredging
7-1	C7-1	08/2020	5.5	0.5	45°20′17″	29°45′57″	dredging
7-2	C7-2	08/2020	5.5	7.5	45°19′75″	29°47′22″	dredging
8	C8	08/2020	10	17.1	45°19′33″	29°47′92″	dredging
10	C10	08/2020	20	17.5	45°19′38″	29°52′26″	dumping
10-2	C10-2	08/2020	22	17.5	45°19′37″	29°52′95″	dumping
10-3	C10-3	08/2020	23	17.7	45°18′96″	29°52′17″	dumping
10- 4	C10- 4	08/2020	19	17.6	45°19′41″	29°51′63″	dumping
6	C6	08/2020	22	16.9	45°19′84″	29°52′27″	background
17	C17	08/2020	23	17.5	45°15′01″	29°50′95″	background
18	C18	08/2020	21	17.6	45°16′36″	29°48′81″	background
19	C19	08/2020	12	17.4	45°17′38″	29°47′17″	background

Mesofauna were stained with Rose-Bengal (0.2 g. l^{-1}). 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 cm^3) and for 1 m^2 of the bottom surface (Vorobyova, 1999). The biomass of nematode species was determined using the Chislenko nomograms (1968).

To identify nematodes, the animals were removed from the sample and placed in a Seinhorst liquid (Seinhorst, 1959) (distilled water – 70 parts, 96% ethanol – 29 parts, and glycerin – 1 part) to clarify them. Then they were placed on a glass slide in a drop of glycerol-gelatin and covered with a cover glass (Platonova, 1968; Vincx, 1996). The preparations were studied using a Konus 5625 Biorex3 light microscope.

For preliminary identification of nematodes, the works of Filip'ev (1918-1921), Platonova (1968) and the NeMys database (Bezerra *et al.*, 2021) were used. The Shannon-Wiener index (H') and Pielou index (J) were calculated to describe the diversity and evenness of the meiofauna and nematode communities.

For the description of the trophic structure of the nematode community, the Wieser (1953) classification was used. Nematode species were classified according to Wieser (1953) into four feeding groups: selective (1A) and non-selective (1B) deposit feeders, epistrate feeders (2A) and omnivores/carnivores (2B).

As functional attributes of the nematode assemblages, the index of trophic diversity (ITD) and the maturity index (MI) were used. The index of trophic diversity (ITD), based on the proportion of each trophic group, was calculated following Heip *et al.* (1985). ITD values range from 0.25 (highest trophic diversity with the four trophic groups accounting for 25% each) to 1.0 (lowest trophic diversity when a single feeding type is present).

The maturity index (MI), derived from life-history characteristics of nematode genera was calculated for each sample according to Bongers (1990) and Bongers *et al.* (1991, 1995). Nematodes were classified along a scale of 1 – 5, with colonisers (inter alia short life cycle, high reproduction rates, high colonisation ability and tolerant to disturbance) weighted as 1 and persisters (inter alia long-life cycles, low colonisation ability, few offspring and sensitive to disturbance) weighted as 5.

EcoQ status was assessed by the number of meiobenthic taxa (richness) as suggested by Danovaro *et al.* (2004), modified according to WFD classes, while the threshold values indicated by Moreno *et al.* (2011) and Semprucci *et al.* (2014a) were applied to assess the EcoQ with nematodes.

BIO-ENV, MDS, ANOSIM, SIMPER test and cluster analysis were done using the Primer® v.6 software package (Clarke and Warwick, 1994; Clarke and Gorley, 2006).

Diversity profiles are visualised using k-dominance curves (Lambshead *et al.,* 1983). Abundance-Biomass Composition plots have been used for revealing disturbances in the structure of meiobenthos and nematode communities (Warwick, 1986; Warwick and Clarke, 1994).

The characteristics of the sediments in these studies are determined by: Konstantinov,1979; Vorobyova and Kulakova, 2009. The sediments of the study area can be divided into 4 main types: As – silty clay (up to 59 % clay); Nsa – sandy-silty clay (up to 22 – 49 % of all fractions); Na – clayey sand (up to 70 % sand) and N – sand (contains up to 78 – 100 % sand.

3. RESULTS

The abiotic factors such as the type of sediment, temperature, depth, salinity and oxygen in relationship with the meiobenthic indices were used to determine the ecological status of the area. In the Bystry arm, where dredging is carried out, sand (N) (42%), silty clay (As) (33%) and clayey sand (Na) (25%) is dominated. Dumping was dominated by sand (N) (50%), sandy-silty, clay (Nsa) (42%). Silty clay (As) (83%), in the area of the fore-delta and the seaward part (background stations).

Based on the calculation of the coefficients (Spearman's rank correlation (ρ_{max}) (BIO-ENV program) by comparing the abiotic matrix from the initial data, including the above 4 physicochemical parameters (except for the type of sediment) and the biotic matrix (by abundance), a combination of two abiotic factors turned out to determine to the greatest extent the quantitative distribution of meiobenthos and nematodes in the study area. The results of the BIO-ENV analysis, where combinations of environmental variables yielded the best match of meiobenthos and abiotic similarity matrices, showed the highest correlation ($\rho_{max} = 0.487$; P = 0.01) with depth and salinity.

Nematode abundance also shows a high correlation with depth and salinity ($\rho_{max} = 0.703$; P = 0.01). The MDS ordination of the abundance of nematode species shows a clear differentiation between the habitats of the communities. So, background and dumping stations (depths 17 – 20 m and 20 – 25 m) are grouped, and the nematode community in the dredging area of depths 5 – 7 m and 7 – 12 m) can be seen separated (Fig. 2).

Meiofauna communities

Eleven meiofauna taxa (Foraminifera, Nematoda, Harpacticoida, Ostracoda, Halacarida, Turbellaria, Kinorhyncha, Oligochaeta, Polychaeta, Bivalvia and Gastropoda) were found in the study area. The number of meiobenthos groups at the stations varied from 0 to 7. Most of them have recorded only 3 to 5 groups. Shannon-Weaver diversity index (H ,) and evenennes (Pielou's (J') scores were generally low (0 to 1.4 and 0 to 1.0, respectively), especially in the dredging sites (Fig. 3, 4).

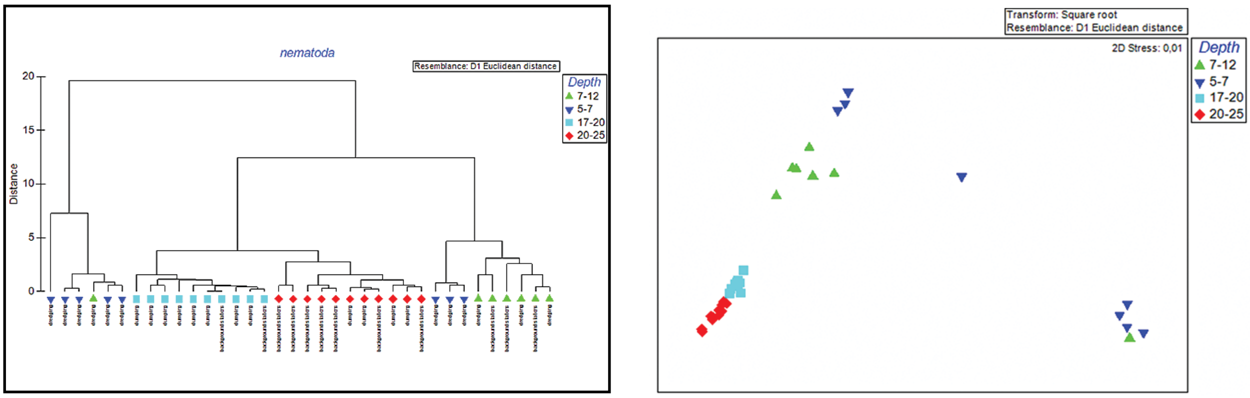

Fig. 2. Cluster analysis and multi-dimensional scaling (MDS) ordination for transformed square root nematode abundance on a two-dimensional scale at each station location.

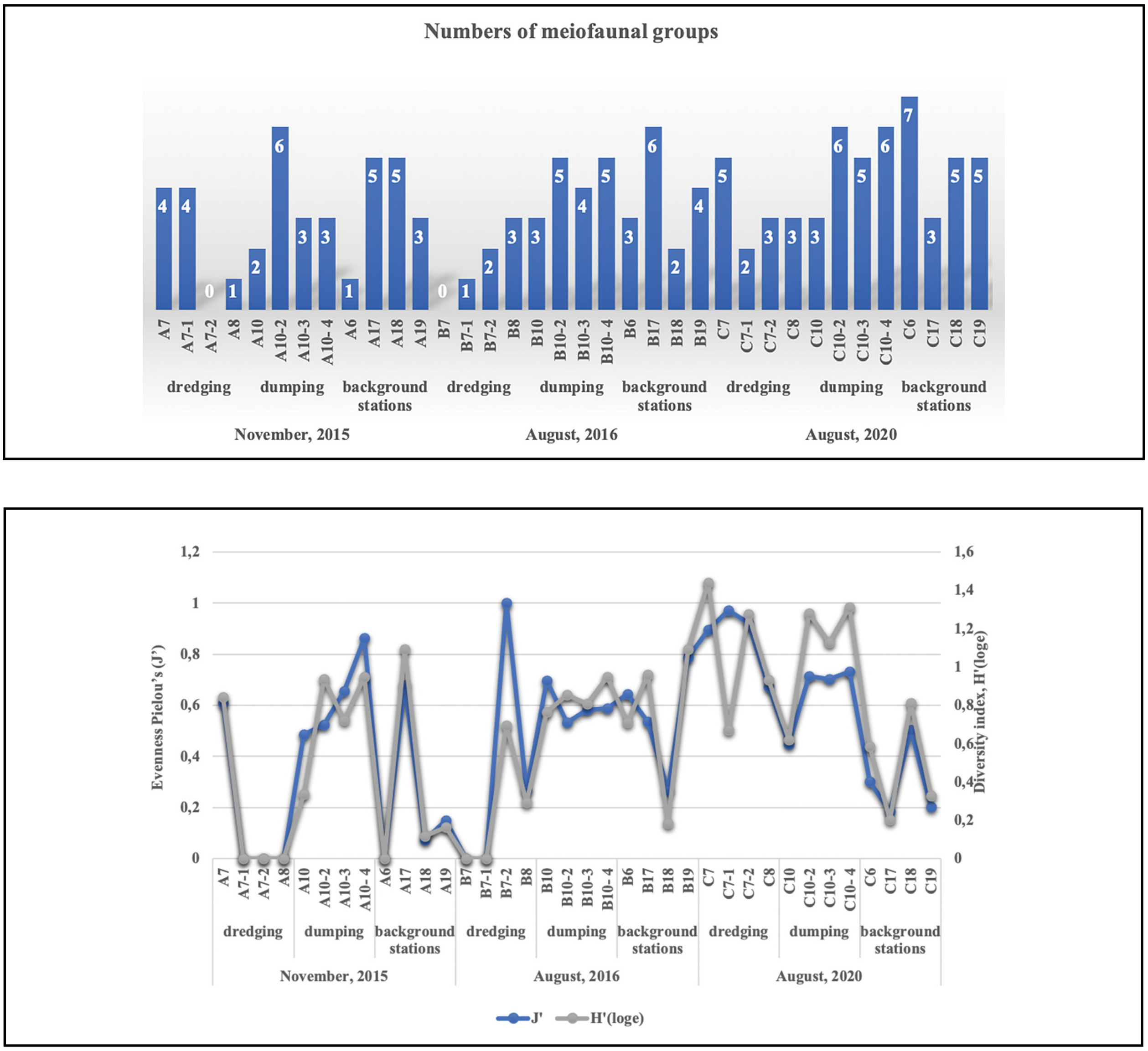

Fig. 3. The number of meiofaunal groups and meiobenthos diversity indices in the study areas.

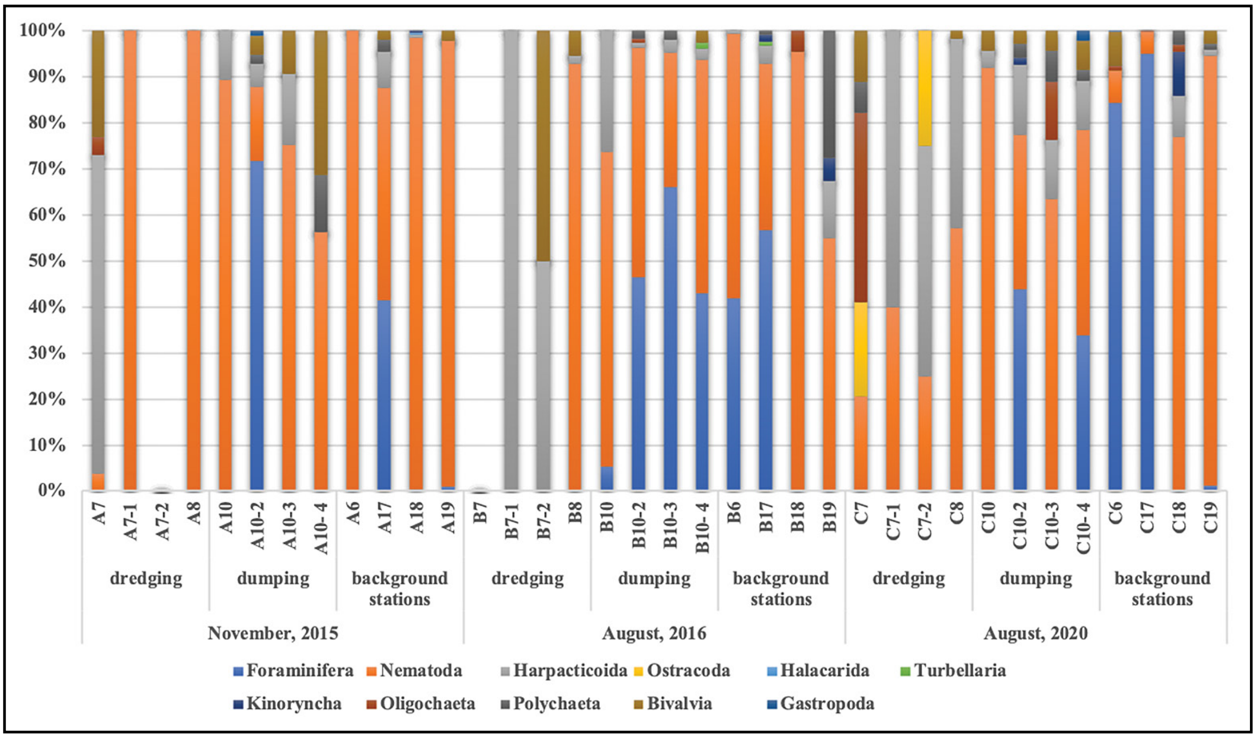

Fig. 4. Composition of the meiofaunal assemblage at all stations.

The results of comparing the quantitative indicators of meiobenthos in different years did not reveal significant deviations (ANOSIM, R = 0.045; P = 9.7). In November 2015, the abundance and biomass of the meiofauna averaged 89241 ± 39812.4 ind./m^2; 248.7 ± 121.9 mg/m^2. In August 2016 and 2020, they were on average 127166 ± 42811.6 ind/m^2; 355.7 ± 169.9 mg/m^2 and 294000 ± 11195.9 ind./m^2; 719.4 ± 436.1 mg/m^2, respectively.

Comparison of the meiobenthos community from different sites (background, dumping, and dredging) revealed a difference in its composition (ANOSIM, R = 0.227; P = 0.001). The R values of pairwise comparison show no statistically significant difference in the meiobenthos composition between dumping and background stations (R = 0.115; P = 0.4) as compared to dredging and dumping (R = 0.242; P = 0.002), on one hand, and dredging and background stations (R = 0.328; P = 0.001), on the other hand.

The MDS plot also shows differences in the composition of meiobenthos taxa between dredging and background stations (Fig. 5).

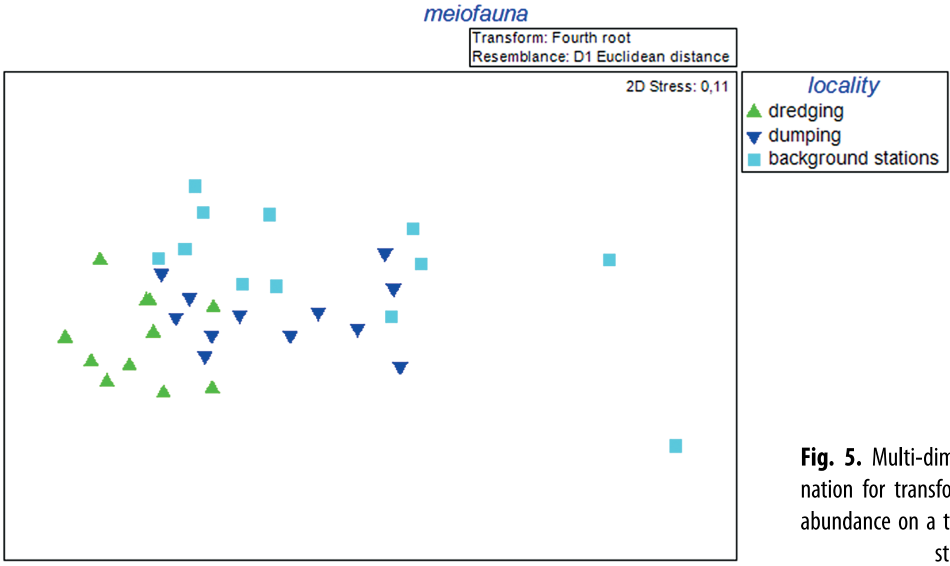

Fig. 5. Multi-dimensional scaling (MDS) ordination for transformed fourth root meiofaunal abundance on a two-dimensional scale at each station location.

It was found that the highest abundance and biomass of meiofauna was observed at background stations (on average 392467 ± 183657.9 ind/m^2; 785.6 ± 512.5 mg/m^2, while the abundance values at the dumping and dredging sites were much lower (on average 96049 ± 28874.4 ind/m^2; 340.0 ± 110.4 mg/m^2 and 22392 ± 13253.8 ind/m^2; 198.4 ± 124.4 mg/m^2, respectively).

In terms of abundance in the meiobenthos community, the eumeiobenthos prevailed, accounting for 92% of the total meiobenthos. According to the frequency of occurrence in one or another period of collection of meiobenthos samples, nematodes (75 – 100%), harpacticoids (50 – 83%) and foraminifera (33 – 50%) dominated (Table 2).

Among the temporary component of meiobenthos (pseudomeiobenthos), polychaetes (25 – 58.3%), oligochaetes (8.3 – 41.7%) and juveniles of bivalve (25 – 66.7%) dominated. The frequency of occurrence of other groups ranged from 0 to 25.0%. In terms of abundance, nematodes (15.1 – 67%) and foraminifera (22.2 – 77.8%) dominated.

The dredging sites were the most impoverished in terms of faunal composition. Only 6 taxa of meiobenthos were recorded. At some stations, meiobenthos was not found at all (stations: A 7-2, November 2015 and B7, August 2016) and where was present, its species richness richness was dominated by nematodes (67.7) and, to a lesser extent, by harpacticoids (58.3%) and bivalvia (41.7 %).

Table 2. Mean relative abundance and frequency of occurrence of meiobenthos in different years

Taxon	Mean relative abundance, %			Frequency of occurrence, %		
	November, 2015	August, 2016	August, 2020	November, 2015	August, 2016	August, 2020
Foraminifera	22.2	40.9	77.8	33.3	50.0	50.0
Nematoda	67.0	51.9	15.1	91.7	75.0	100.0
Harpacticoida	5.6	3.3	1.8	50.0	83.3	75.0
Ostracoda	0.0	0.0	0.2	0.0	0.0	25.0
Halacarida	0.1	0.0	0.0	8.3	0.0	0.0
Turbellaria	0.0	0.3	0.0	0.0	16.7	0.0
Kinoryncha	0.1	0.5	0.2	8.3	16.7	16.7
Oligochaeta	0.1	0.3	0.7	8.3	16.7	41.7
Polychaeta	1.3	2.1	0.3	25.0	33.3	58.3
Bivalvia	3.4	0.8	3.8	50.0	25.0	66.7
Gastropoda	0.2	0.0	0.1	8.3	0.0	16.7

Nine groups of meiobenthos were found in the dumping area. The nematodes were prevalent (100%), followed by harpacticoids (91.7%) and foraminifera (58.3%). The frequency of occurrence of other groups of meiobenthos was also high (juveniles of bivalvia 66.7%, polychaetes (58.3%). Nematodes (44.1%) and foraminifera (43.9%) dominated in density. At the background stations, an increase in the diversity of meiobenthos was observed up to 11 taxa (Table 3).

Table 3. Mean relative abundance and frequency of occurrence of meiobenthos on the different sites

Taxon	Mean relative abundance, %			Frequency of occurrence, %		
	Dredging	Dumping	Background stations	Dredging	Dumping	Background stations
Foraminifera	0	43.9	65.83	0	58.3	66.7
Nematoda	67.0	44.1	28.75	66.7	100.0	100.0
Harpacticoida	22.3	5.6	1.06	58.3	91.7	58.3
Ostracoda	1.5	0.0	0.03	16.7	0.0	8.3
Halacarida	0.0	0.0	0.02	0.0	0.0	8.3
Turbellaria	0.0	0.2	0.04	0.0	8.3	8.3
Kinoryncha	0.0	0.1	0.32	0.0	8.3	33.3
Oligochaeta	2.6	0.4	0.40	16.7	16.7	33.3
Polychaeta	0.4	1.8	0.77	8.3	58.3	50.0
Bivalvia	6.3	3.1	2.74	41.7	66.7	33.3
Gastropoda	0.0	0.8	0.02	0.0	25.0	8.3

Nematofauna communities

The nematofauna of the study area was represented by 46 species from 29 genera, 17 families, and 5 orders (Table 4). The species belonging to orders Monhysterida and Enoplida reached the highest numbers. The species richness in order Monhysterida varied from 9 at dredging, to 11 and 13 species at dumping and background stations, respectively. The number of species in order Enoplida increased from 3 to 15 in the dredging site as compared to the background stations. The order Chromadorida also recorded a large number of species in the area of dumping and background stations.

It should be noted the low species diversity of nematodes in all studied areas (Fig. 6). Shannon index (H') values in the dredging area varied from 0 to 1.8. The values of the Pielou's evenness index (J) varied from 0.94 to 1. At dumping sites (H'= 1.4 – 2.3; J = 0.98 – 0.99) and background stations (H' = 1.1 – 2.5; J = 0.95 – 0.99) species diversity increases.

A comparison of the study sites in terms of nematode abundance revealed a high average Bray-Curtis similarity between the background stations and dumping areas (57.2%). A smaller value of the similarity index was found between dredging and background stations (22.8%). Thus, the abundance in the dredging area varied from 0 to 120,037 ind / m^2, on average 11,250 ± 10,059.1 ind / m^2. On dumping, the abundance of nematodes was almost 4 times higher than in the dredging area, varying from 0 to 208,266 ind / m^2 and on average 42,877 ± 18,596.4 ind / m^2.

In the area of background stations, the nematodes abundance ranged from 0 to 670,263 ind / m^2, and recorded a maximum average value of (111,189 ± 18,596.4 ind / m^2).

When comparing the community of nematodes in different years, the k-dominance curves showed the highest species diversity in August 2020. It was also noted that at the stations where claey sand (Na) prevailed, the diversity of nematodes was significantly lower than in other types of sediments (Fig. 7).

When comparing the community of nematodes from different sites (background, dumping, and dredging), a difference in its composition was found (ANOSIM, R = 0.269; P = 0.01). The R values of pairwise comparison show a smaller difference in nematode composition between dumping and background stations (R = -0.026; P = 0.7) than between dredging, dumping (R = 0.372; P = 0.01), dredging and background stations (R = 0.405; P = 0.01) regions.

Differences were found in the nematode community at stations with different depths (ANOSIM, R = 0.368; P = 0.01). The R values of pairwise comparison show significant differences in the nematode community between stations with depths of 5-7 and 17-20 (R = 0.695; P = 0.01) and 5-7 and 20-25 m (R = 0.733; P = 0.01), but not between stations with depths of 17-20 and 20-25 (R = -0.029; P = 0.6). The MDS plots also show differences in the composition of the nematode community between dredging and background stations (Fig. 8).

The k-dominance curves (Fig. 9) also indicate the predominance of nematode species in the sites of background stations and dumping compared to the dredging site.

In the dredging site, there is a pronounced dominance of only two species – up to 80% (*Monhystera rotundicapitata*, *M. conica*). We assume that the dominance of nematode abundance (Fig. 9) could be associated with environmental conditions. At background stations and dumping, 5-6 species determine 80% of their dominance. High values of the average similarity, estimated by the Bray-Curtis coefficient, were noted for background station (31.9%) and dumping (31.5%). In the dredging area, the mean similarity is low (1.1%).

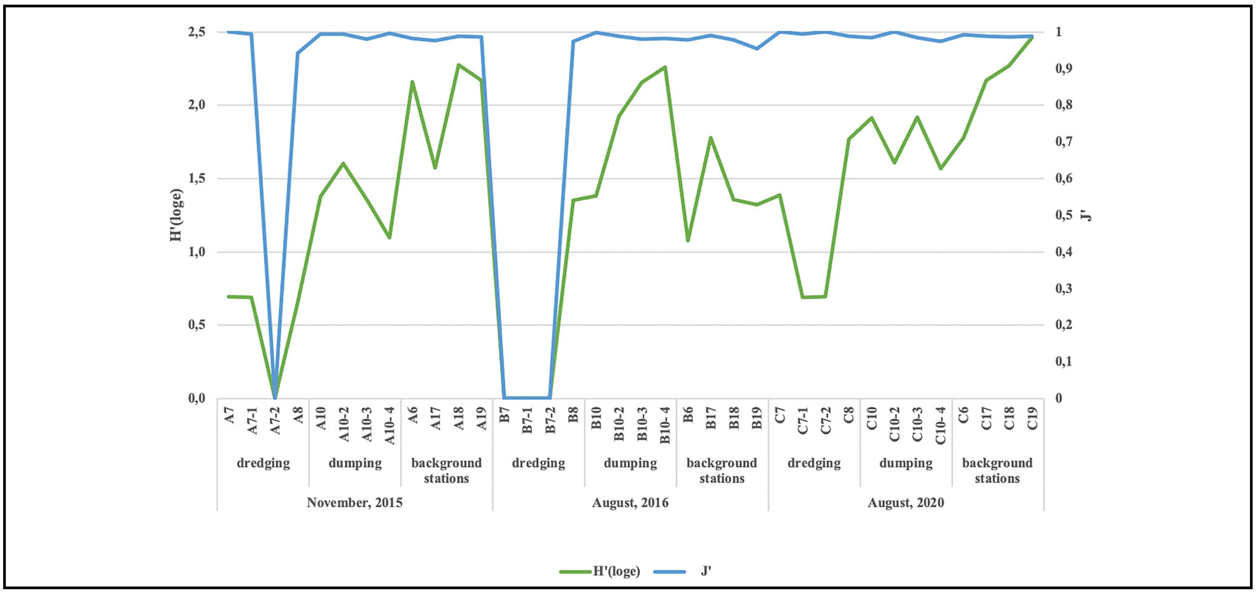

Fig. 6. Species diversity of nematodes (Shannon index, H' and Pielou evenness index, J) in the study areas.

Table 4. Feeding types (FT) and mean relative abundance of nematodes species at the different sites of the Danube delta

Species	FT	Dredging	Dumping	Background stations
		Mean relative abundance, %		
Enoplus littoralis Filipjev 1918	2B	0	0.3	0.3
E. quadridentatus Berlin 1853	2B	0	0	0.2
Enoploides brevis Filipjev 1918	2B	0	0	0.1
Oxyonhus dubius (Filipjev 1918)	2B	0	0	0.3
*Mesacanthion conicum (*Filipjev 1918)	1A	0	0	0.8
Anoplostoma viviparum (Bastian 1865)	2A	5.6	0.4	0.1
Phanoderma albidum Bastian 1865	1A	0	0	0.4
Anticoma acuminata (Eberth 1863)	2B	0	0.8	0.3
Viscosia glabra (Bastian 1865)	2B	0	0	2.9
V. elongata Filipjev 1922	2B	0	0	0.9
V. minor Filipjev 1918	2B	0.7	1.3	2.3
Oncholaimus campylocercoides De Coninck end Stekhoven 1933	1A	0	0	4.3
Oxystomina elongata (Butschli 1874)	1A	0	0	1.5
Halalaimus ponticus Filipjev 1922	1B	0	0	1.7
Bathylaimus cobbi Filipjev 1922	2A	0	1.4	0.3
Chromadora nudicapitata (Bastian 1865)	2A	0	0.1	1.7
Chromadorella mytilicola (Filipjev 1918)	2A	0	0	0.3
Euchromadora striata (Eberth 1863)	2A	0	0.4	0.3
Chromadorina gracilis (Filipjev 1922)	2A	0	0.3	0
Chromadorita leucarti (De Man 1876)	2A	0	0.4	0.3
Neochromadora poecilosomoides (Filipjev 1918)	2A	0	4.9	3.2
Paracantonchus caecus (Bastian 1865)	2A	7.4	2.2	0.8
Cobbionema acrocerca Filipjev 1922	1A	0	0	2.6
Microlaimus kaurii Wieser 1954	1B	0	4.4	3.5
Monhystera collaris Filipjev 1922	1B	3.7	0.4	1.7
M. conica Filipjev 1922	1B	16.3	0.4	0.7
M. longicapitata Filipjev 1922	1B	0.6	0	0
M. ampulocauda Paramonov, 1926	1B	0.4	0	0
M. rotundicapitata Filipjev 1922	1B	1.0	0	0.4
Monhystera sp. 1	1B	0.6	0	0
Monhystera sp. 2	1B	0.4	0	0
Daptonema longicaudatum (Filipjev, 1922)	1B	0.4	0	0
D. maeoticum (Filipjev, 1922)	1B	0	0.3	0.2
Theristus setosus Butschli 1874	1B	0.1	0	0
T. latissimus Filipjev 1922	1B	0.5	0	0.2
Theristus sp.	2B	0	0.9	0
Sphaerolaimus gracilis De Man 1976	2B	0	2.5	1.0
S. ostreae Filipjev 1918	2A	0.1	3.3	4.5
Metalinhomoeus zosterae Filipjev 1918	1A	0	0.8	0.3
Terschellingia pontica Filipjev 1918	1B	0	16.4	14.6
Axonolaimus ponticus Filipjev 1918	1B	0	7.3	7.5
A. setosus Filipjev 1918	1B	0.4	6.8	0
Parodontophora quadristicha (Stekhoven 1950)	1B	0	0	0.8
Sabatieria abyssalis (Filipjev, 1918)	1B	0	1,1	0
S. pulchra (Filipjev, 1918)	1B	61.0	42.1	38.7
Sabatieria sp.	1B	0.6	0.9	0

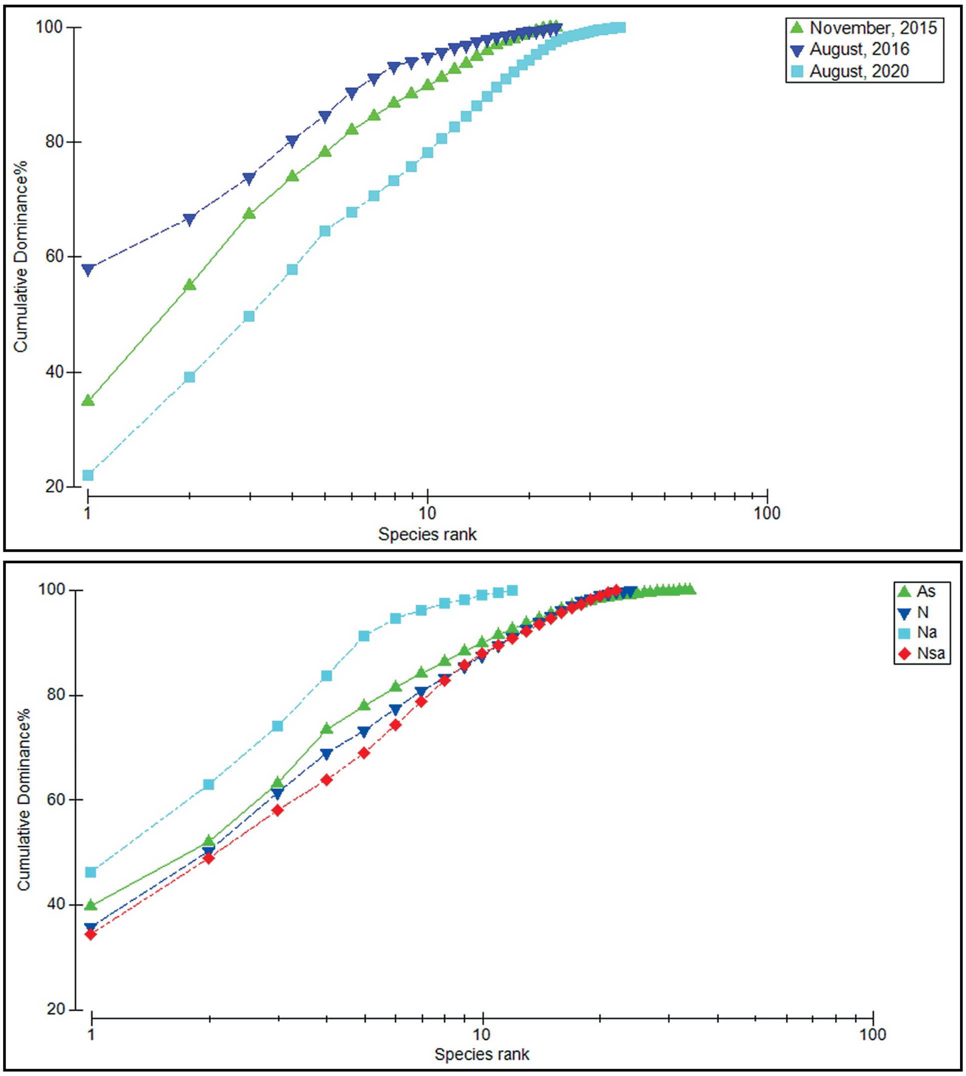

Fig. 7. Ranked species K-dominance curves for the free-living nematode species in the different years and type of sediment (silty clay (As); sand (N); clayey sand (Na); sandy-silty, clay (Nsa).

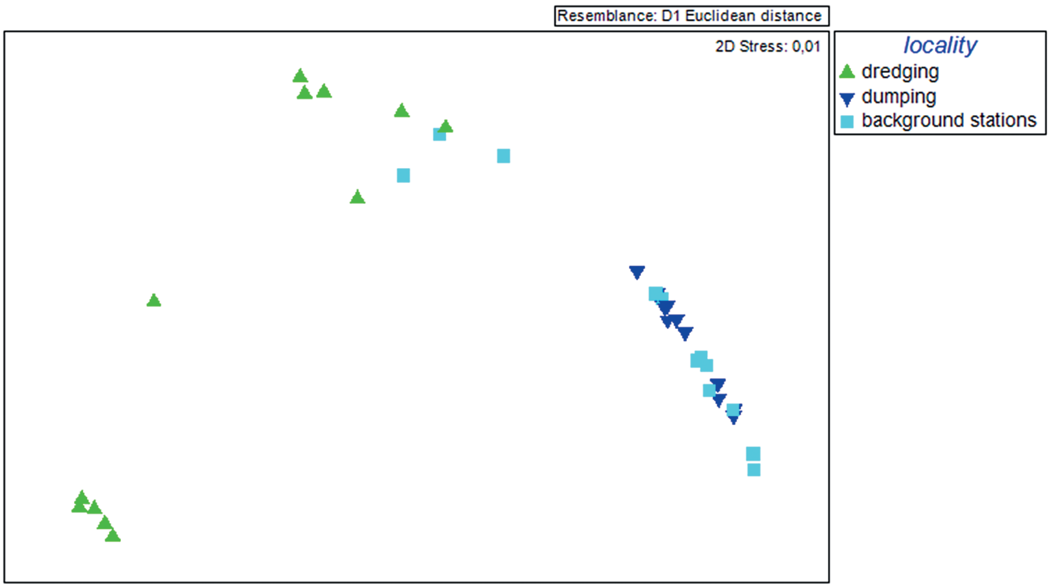

Fig. 8. Multi-dimensional scaling (MDS) ordination for transformed square root nematode abundance on a two-dimensional scale at each station location.

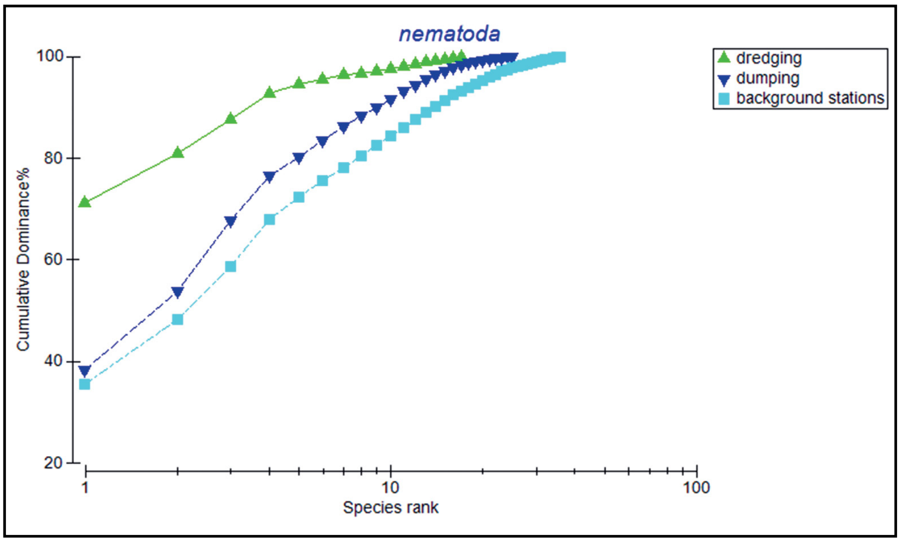

Fig. 9. K-dominance curves of nematode assemblage for different sites.

This may indicate unstable conditions in this water area associated with the peculiarities of hydrological and hydrochemical parameters (high flow rates and sedimentation processes, salinity, and the quantity of organic matter), which affect the development of nematodes.

Taxonomic complexes of nematodes have been identified for each site. The analysis of the average similarity within these complexes, as well as the contribution of individual species to the intracomplex similarity (indicator species) and to the intercomplex dissimilarity (discriminator species), were performed based on the values of the similarity (S) or dissimilarity (D) functions (*Simper* program).

In the dredging sites, only 3 species out of a total of 17 made up 100% of the cumulative contribution to the intercomplex average similarity: *M. rotundicapitata*, *M. conica*, and *Sabatieria pulchra*. Their relative contributions to the intracomplex similarity were 39.9, 34.0, and 26.0%, respectively. However, these species have low similarity (S) values (0.5, 0.4, and 0.3, respectively), which indicates unstable parameters of environmental conditions in this water area.

At dumping stations, 90.9% of the cumulative contribution is formed by 4 species (out of a total of 25): *S. pulchra*, *Terschellingia longicaudata*, *Sphaerolaimus ostreae*, and *Axonolaimus ponticus*. *S. pulchra* dominated as relative contribution to the average similarity (61.8%) as well as the similarity index S (19.5) followed by *T. longicaudata* with a relative contribution to the average similarity of (20.0%) and 6.3, in terms of similarity S respectively. The share of the contribution of the rest of the species decreases from 5.83% in case of *S. ostreae* to 3.3% for *A. ponticus*. They also have low S values (1.8, 1.0, respectively).

In the sites of background stations, the most significant were 3 species (out of a total of 35), making up to 92.2% of the cumulative contribution to the average similarity. *S. pulchra* (67.9%, 21.7) and *T. longicaudata* (20.7%, 6.6) are leading in terms of the relative contribution and S indices. *A. ponticus* accounted for only 3.6% of the relative contribution to the intracomplex mean similarity and a low similarity score S (1.0).

Out of all nematode species, only one species was common to all three regions: *S. pulchra*. However, it makes the largest contribution to the average similarity between stations on dumping and background stations, ranging from 61.8 to 67.9%, respectively. In the dredging area, the role of this species decreases to 26.0%.

When comparing taxonomic complexes of nematodes from different sites of the study, the greatest values of the level of dissimilarity were highlighted when comparing complexes dredging & dumping (D = 96.4%) and complexes dredging & background stations (D = 96.6%). Somewhat smaller – between complexes dumping & background stations (D = 71.5%). The most significant species – discriminators, making 59.6% of the cumulative contribution to the dissimilarity between complexes dredging and dumping, are 3 species: *S. pulchra* (37.7%, 36.4), *T. longicaudata* (15.8%, 15.2), and *A. ponticus* (6.5%, 6.3). Dissimilarity in the taxocene of nematodes between dredging and background stations are introduced by the same species: *S. pulchra* (38.7%, 37.4), *T. longicaudata* (14.1%, 13.6), and *A. ponticus* (7.7%, 6.3). Their cumulative contribution, the dissimilarity between these sites was 60.5%. Note also that the average density of *S. pulchra* reached the highest values at the dumping, and in the area of background stations it was an order of magnitude higher. *T. longicaudata* and *A. ponticus* were not found in the dredging area.

When comparing the taxocene of nematodes between the sites of dumping and background stations, 3 discriminator species were identified that make the greatest contribution excedent to their dissimilarity (51.4%). These are the species: *S. pulchra* (37.7%, 36.4), *T. longicaudata* (15.8%, 15.2) and *A. ponticus* (6.5%, 6.3). The highest indicators of their average density were in the area of background stations.

The results of the analysis show that the species marked with the greatest contribution to the average intra-complex similarity (S) – indicator species in a particular area simultaneously act as discriminator species, reaching the maximum values of the dissimilarity function (D). For the study areas, species have been identified that can be considered as potential indicators. Thus, in the taxocene of the dredging sites, these are *M. rotundicapitata*, *M. conica*, and *S. pulchra*. In the dumping sites, these are *S. pulchra*, *T. longicaudata*, *S. ostreae*, and *A.* ponticus. In the area of background stations – *S pulchra*, *T. longicaudata* and *A. ponticus*.

According to the type of feeding, four trophic groups of nematodes were found and the Index of Trophic Diversity (ITD) was calculated based on their predominance between stations (Fig. 10). The 1B = non-selective deposit feeders dominated at most stations. In the dredging sites, they averaged 59.6 ± 13.4%. *M. conica* and *S. pulchra* prevailed in density. Selective deposit feeders (1A) accounted for only 4.2%. The dumping was also dominated by non-selective deposit feeders (57.7 ± 5.3%), *S. pulchra* and *A. ponticus,* the species with one of the highest densities as well.

An increase in the role of selective deposit feeders (1A) (23.4 ± 5.4%) was also noted, with *T. longicaudata* dominating in density. The share of epistrate feeders (2A) is increasing (8.8 ± 3.5%). Of these, the species *Neochromadora poecilosomoides* stands out in terms of density. Predators (2B) were 10 ± 2.6%. At the background stations, a high proportion of selective deposit feeders was also noted as compared to the dredging sites - 21.9 ± 3.4%. Of these, *S. pulchra* and *A. ponticus* dominated in density. Non-selective deposit feeders (1B) in this area amounted to 52.4 ± 6.4%, dominated by *T. longicaudata*. As in the case of dumping, an increase in the proportion of epistrate feeders (2A) (11.5 ± 3.6%) and predators (2B) 14.6 ± 3.4% was noted. Among the epistrate feeders (2A), the predominant species was *N. poecilosomoides*. The predators (2B) were dominated by *S. ostreae* and *S. gracilis*.

The trophic diversity index (ITD) in the study area varied from 0.28 to 1. In the dredging sites, the average ITD values were 0.6 ± 0.1. At dumping and background stations, they were lower and amounted to 0.49 ± 0.04 and 0.44 ± 0.05, respectively.

A maturity index (MI), which is a potential indicator of nematode community under stress, was calculated for the three study sites (Fig. 11). Class c-p1 representatives were absent. Class c-p2 was the most common in all areas and showed high values. In particular, c-p3 turned out to be significant only in the dumping sites and background stations. In these sites, classes c-p4, c-p5 were also recorded at several stations, while they were not on the dumping.

Average values of the maturity index varied from (1.5 ± 0.2) in the dredging sites, to 2.3 ± 0.1 at dumping and 2.6 ± 0.1 at background stations.

In these studies, a method for assessing the ecological quality status (EcoQ) of the aquatic environment of the coastal area of the Danube delta was tested using the example of the meiobenthos and nematode communities. Meiobenthic richness (S), Shannon diversity index (H'), Pieloux evenness index (J), maturity index (MI), cp%, feeding groups, trophic diversity index (ITD) was calculated for three different sites of the coast area of the Danube delta (Table5).

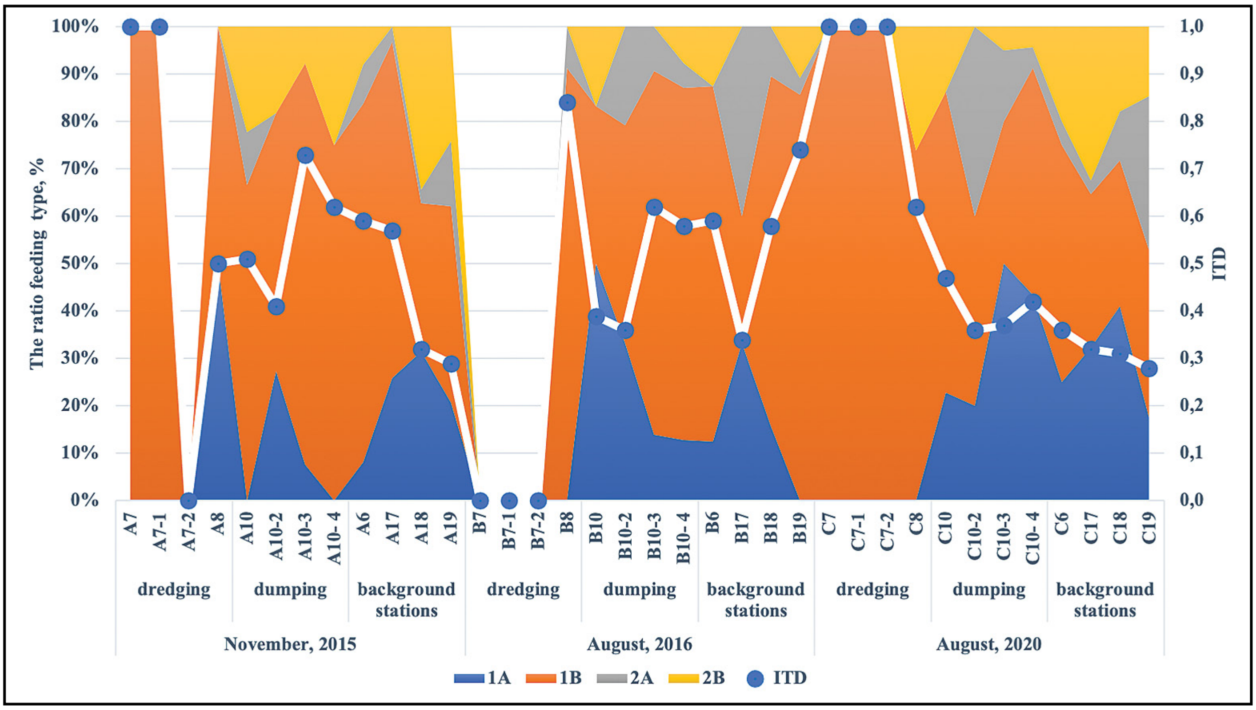

Fig. 10. Trophic composition of the nematode community. Based on the feeding guilds of Wieser (1953): **1A** = selective deposit feeders, **1B** = non-selective deposit feeders, **2A** = epistrate feeders, **2B** = predators and Trophic Diversity Index (ITD).

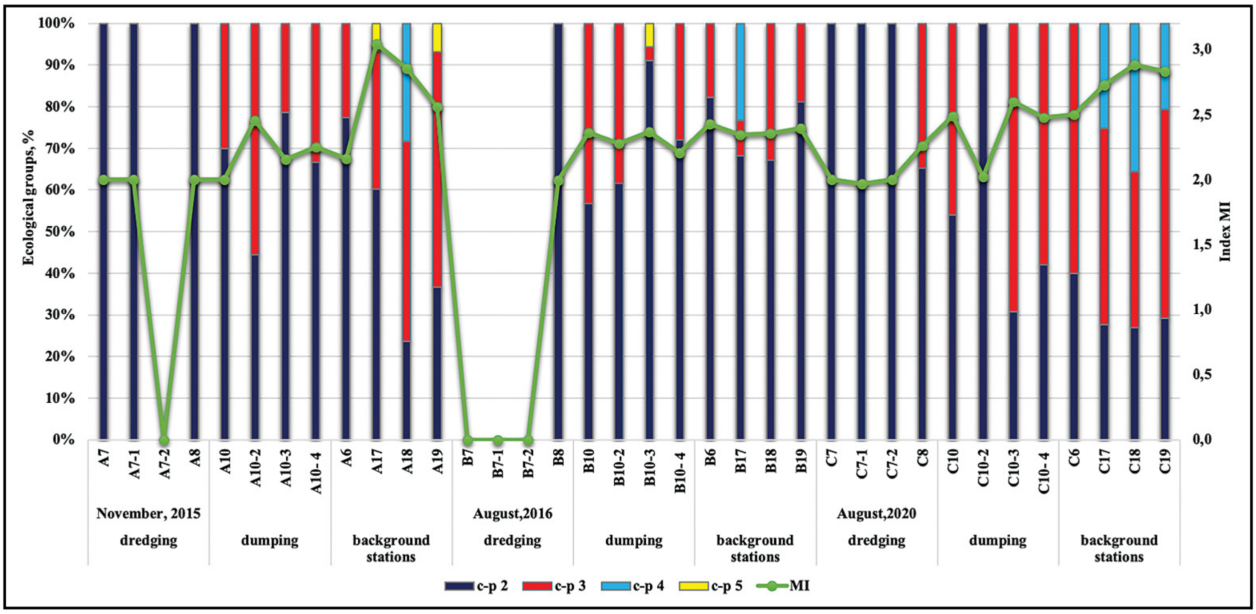

Fig. 11. Percentage of nematode coloniser-persisters classes revealed in the study area and Maturity index (MI).

Table 5. Meiobenthic richness (S), Shannon's diversity index (H'), Pielou's evenness index (J), maturity index (MI), cp%, feeding groups (food groups), trophic diversity index (ITD) calculated for three different areas of the coast area of the Danube delta

Faunal parameters	Dredging	Dumping	Background stations
Meiobenthic richness (S)	6	9	11
Nematode Shannon index (H')	0.7±0.2	1.7±0.1	1.9±0.1
Nematode Pielou index, J	0.7±0.1	1.0±0.0	1.0±0.0
Nematode maturity index (MI)	1.5±0.2	2.3±0.1	2.6±0.1
c-p1	0	0	0
c-p2	61.0±10.3	64.0±5.8	51.8±6.7
c-p3	2.9±3.3	35.5±6.0	36.0±4.8
c-p4	0	0	11.1±4.1
c-p5	0	0.5±0.5	1.1±0.8
1A	4.2±4.2	23.4±5.1	22.0±3.4
1B	59.6±13.4	57.7±5.3	52.4±6.4
2A	0.7±0.7	8.8±3.5	11.1±3.6
2B	2.2±2.2	10.0±2.6	14.6±3.4
ITD	0.6±0.1	0.5±0.1	0.4±0.1

To assess the EcoQ (ecological quality) classes of the study area, the threshold values of these indices proposed by Danovaro *et al.* (2004), Moreno *et al.* (2011) and Semprucci *et al.* (2014a, b) (Table 6).

Meiobenthos is characterized by 11 taxonomic groups. The values of the taxonomic richness of the meiobenthos varied from 6 taxa in the dredging area to 9 taxa at background stations (Table 5). Applying the ecological quality classification (EcoQ) based on this variable of meiobenthos, the study area falls into the status of Poor (dredging) to Moderate (the other areas). It should be noted that the species diversity of nematodes is low in all the regions under study. The Shannon index (H') in the dredging area ranged from 0 to 1.8. On average, it ranged from 0.7 ± 0.2 in the dredging area to 1.9 ± 0.1 at background stations. Low values of these indices indicate Bad ecological status in the dredging area and Poor in the rest. A high content of c-p2 (r-strategists) was noted, especially in the dredging and dumping areas, which gives grounds to classify these areas as Poor.

At the site of the background stations, the content of c-p2 decreases (51.8 ± 6.7), which indicates a Moderate ecological state. Average values of the maturity index (MI) varied from (1.5 ± 0.2) in the dredging area to 2.3 ± 0.1 at dumping and 2.6 ± 0.1 at background stations. According to the thresholds shown in Table 5, the Maturity Index values also indicate that the dredging area is in Bad condition, the dumping area is in Poor, and the background stations can be classified as Moderate. The 1B = non-selective deposit feeders dominated at most stations. Average ITD values in the dredging site were 0.6 ± 0.1. At dumping and background stations, these were lower and amounted to 0.5 ± 0.1 and 0.4 ± 0.1, respectively. According to the values of the trophic diversity index (ITD), the study area can be classified as Poor.

Table 6. Thresholds considered to evaluate the EcoQ of the study area according to Danovaro *et al.* (2004), Moreno *et al.* (2011) and Semprucci *et al.* (2014a, b)

Faunal parameters	High	Good	Moderate	Poor	Bad
Meiobenthic richness (S)	≥16	16<S<12	8<S<11	4<S<7	≤4
Nematode Shannon index (H')	>4.5	3.5<H<4.5	2.5<H'<3.5	1<H'≤2.5	0<H'≤1
Nematode maturity index (MI)	>2.8	2.8≤MI<2.6	2.6≤MI<2.4	2.4≤MI<2.2	≤2.2
Nematode c-p 1 and c-p 2	0–20 %	20–40 %	40-60	60-80	80-100
Nematode c-p 3 and c-p 4	80–100 %	60–80 %	60-40	20-40	0-20
ITD	0.25	0.25<ITD≤0.4	0.4<ITD≤0.6	0.6<ITD≤0.8	1

4. DISCUSSION

The northwestern part of the Black Sea is characterized by low salinity, and this is reflected both in the species diversity of meiobenthos and in the quantitative index, especially in areas subject to the intense influence of river runoff (Vorobyova and Kulakova, 2009; Kulakova, 2006, 2020). The results of the BIO-ENV analysis, where combinations of environmental variables yielded the best match of meiobenthos and abiotic similarity matrices, showed the highest correlation with depth and salinity (ρ_{max} = 0.487). The abundance of nematodes also shows a high level of correlation with depth and salinity (ρ_{max} = 0.703). The results of comparing the abundance of meiobenthos in different years did not reveal significant deviations (ANOSIM, R = 0.045; P = 9.7). Multivariate analysis of the taxonomic composition of the meiobenthos showed differences between dredging and background stations (R = 0.328; P = 0.001).

The Shannon–Weaver index (H') and evenness (Pielou's (J') indices for meiobenthos were generally low (0 to 1.4 and 0 to 1.0, respectively), especially at the dredging site. Nematodes dominated in occurrence. The abundance was formed mainly by nematodes and, to a lesser extent, by harpacticoids. In the dumping area and background stations, nematodes, harpacticoids, and foraminifers also dominated in terms of occurrence, but along with them, the role of juveniles of bivalvia and polychaetes increased.

Abundance-Biomass Comparison plots proposed by Warwick (1986) also indicate disturbances in the structure of the meiobenthos community in these studies. K-dominance curves for biomass and abundance (ABC curves) from different areas show that the meiobenthic community is subject to pollution (the biomass curve lies below the density curve) (Fig. 12).

The discovery of differences in meiobenthos diversity in the study areas highlights the importance of using meiofauna as good indicators of environmental conditions, as changes in their density, diversity, structure and function may indicate changes in the study area (Heip *et al.,* 1985; Coull and Chandler, 1992; Danovaro *et al.*, 2008; Moreno *et al.*, 2008; 2011; Semprucci and Balsamo, 2014; Semprucci *et al.* 2019).

Free-living nematodes were found to be the dominant meiofauna in this study, and their density and diversity decreased towards the oligohaline zone (to which the dredging site belongs). Several authors also note that the nematodes decrease towards the oligohaline zone and they were dominant in the estuarine environment (Soetaert *et al.*, 1994; Udalov *et al.,* 2005; Paerl, 2006). Low occurrence of meiofaunal groups and high percent dominance of nematodes suggests sensitivity of other meiofaunal groups to dynamic habitat compared to nematodes (Heip *et al.*, 1985; Coull and Chandler, 1992).

The qualitative composition of meiobenthos is also affected by the composition of bottom sediments. This study it was noted that the area of the shipping channel, where dredging works are carried out, is characterized by depleted nematofauna both in qualitative and quantitative terms.

The discharge or loss of fine dense sand during dredging into the dumping area creates unfavorable conditions for the development of meiobenthos in it. At background stations, with a predominance of silty fractions in bottom sediments, an increase in the density and species diversity of nematodes is observed. This confirms the fact that granulometric deposits are the dominant factor in determining the composition of nematode communities (Tietjen, 1977).

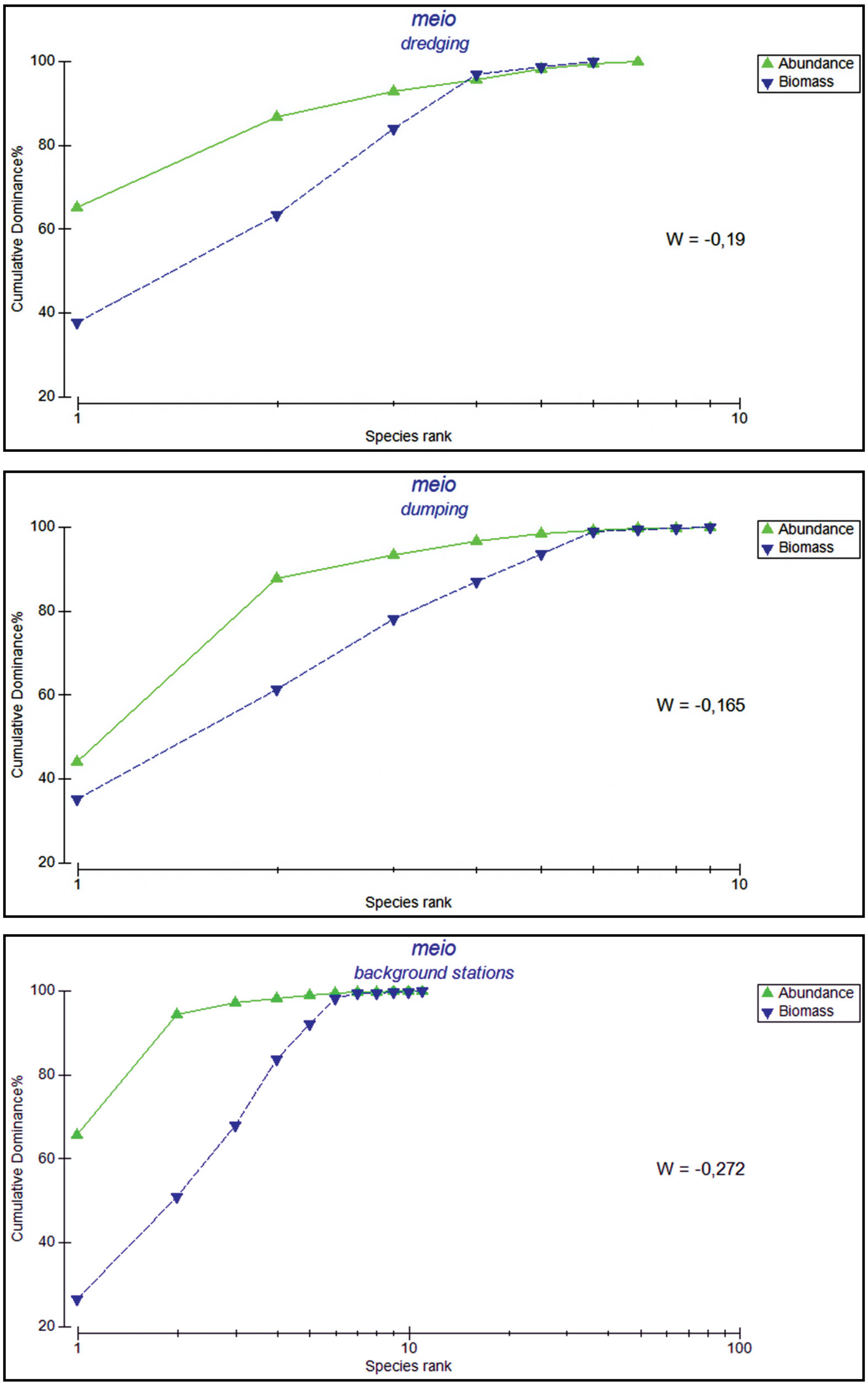

Fig. 12. K-dominance curves for biomass and abundance (ABC curves) of meiobenthos from different areas.

The composition of nematodes is mainly determined by the grain size of the sediment (Vanaverbeke *et al.*, 2011). Food source is also an important aspect for the distribution of nematode species (Moens *et al.*, 1999).

When comparing the structural features of the nematode taxocene within each of the three selected sites, high values of the average similarity, estimated by the Bray-Curtis coefficient, were noted for background station (31.9%) and dumping (31.5%). In the dredging sites, the mean similarity value is low (1.1%). This may indicate unstable conditions in this water area, associated with the peculiarities of hydrological and hydrochemical parameters, as well as dredging (disturbance of sediments), affecting the development of nematodes. When comparing taxonomic complexes of nematodes from different areas of the study, the highest values of the level of difference were identified when comparing the groups dredging & dumping (D = 96.4%) and groups dredging & background stations (D = 96.6%) Somewhat lower values were found between groups dumping & background stations (D = 71.5%).

A rather high level of dissimilarity between the dredging sites and the sites of dumping and background stations indicates the existing differences in the species structure and quantitative development of the nematode taxocene in the analyzed areas. The Danube delta coastal area is a zone of constant interaction of river and sea waters, as a result of which their properties change, which affect the formation of quantitative and qualitative indicators of the nematofauna (Kulakova, 2020).

Among the 46 nematode species found in the study areas, several species can be considered as potential indicators. So, in the taxocene of the dredging sites, these are *Monhystera rotundicapitata*, *M. conica* and *Sabatieria pulchra*. In the dumping sites – *S. pulchra*, *Terschellingia longicaudata*, *Sphaerolaimus ostreae* and *Axonolaimus ponticus*. In the sites of background stations – *S. pulchra*, *T. longicaudata* and *A. ponticus*. The dominant species found in this study are typical of silt or fine sand worldwide, as stated in the papers (Heip *et al.*, 1985; Soetaert and Heip, 1995; De Leonardis *et al.*, 2008; Semprucci *et al.*, 2010; Muthumbi *et al.,* 2011).

Ecologically, *Monhystera rotundicapitata* and *M. conica* are characteristic oligotrophic freshwater forms that intensively develop in desalinated water bodies (Lorenzen, 1978). *Sabatieria* is a genus that indicates poor ecological quality of the environment, because of its well-known tolerance to pollution (Moreno *et al.* 2011). The presence of *T. longicaudata* in heterogeneous habitats proves its ubiquitous distribution in the marine sediments (Hodda and Nicholas, 1985), various subtidal habitats (Heip *et al.*, 1985; Schratzberger *et al.*, 2004, 2006.) The species is also known to excel in anthropogenically disturbed and polluted habitats (Lambshead, 1986; Schratzberger & Warwick, 1998; Liu *et al.,* 2008).

Sabatieria pulchra, Terschellingia longicaudata and *Axonolaimus ponticus* were noted among the dominant 1B = non-selective deposit feeders at most stations. Studies of the nematofauna in the Romanian part of the Danube Delta also noted the dominance of non-selective deposit feeders (mainly from the families Comesomatidae and Linchomoidae) in shallow water, which is under the strong influence of the Danube and at great depths with silt deposits enriched with organic matter (Muresan and Teaca, 2019).

A high content of c-p2 (r-strategists) was found in all areas, as well as the lowest MI values in the dredging area. This may indicate an unstable habitat. Thus, it was noted that the number of nematodes classified as c-p2 increases in stressful or eutrophic conditions. (Warwick, 1986).

The increase in the content of representatives of c-p3 and the appearance of c-p4 (k strategists) as well as MI values at dumping and especially at background stations may indicate relatively moderate conditions in these areas compared to dredging. According to Moreno *et al.*, (2011), analysis of the percentage composition of the various c–p classes at each site allows a better classification of the studied sites than the application of MI. The authors (Bongers *et al.* 1991; Sandulli *et al.,* 2014; Moreno *et al.*, 2011) also note that relatively low MI values may be characteristic of nematode communities in estuarine areas, reflecting the harsh conditions of this environment.

Using the classification of ecological quality (EcoQ), based on the values of the taxonomic richness of the meiobenthos, the study area falls into the class from Bad (dredging) to Moderate (other areas). According to the Shannon Diversity Index (H'), Pielou's Evenness Index (J), Maturity Index (MI), cp%, Feeding Groups, Trophic Diversity Index (ITD) of nematodes, the dumping and background stations can be generally classified as Poor and the dredging site as in Bad ecological status.

Studies conducted in the Romanian part of the Danube Delta also indicate the dominance of the trophic structure of the c-p2 nematodes and the low index MI, which gave grounds to determine the status of the ecological quality (EcoQ) of the study area as Bad (Muresan *et al.* 2019).

The results of studies of free-living marine nematodes inhabiting shallow waters (3 m) of Sinop Bay (Southern Black Sea, Turkiye) also showed the possible use of the MI and the percentage of c-p class percentages to identify the ecological quality status of benthic environments according to Water Framework Directive (Ürkmez *et al.* 2014).

Modern data on the poor ecological state of the Danube estuary, based on the use of the above indices, confirm the results of long-term monitoring of this area. Thus, studies of early years found that the maximum concentrations and greater diversity were noted at stations located in open areas of the northwestern shelf on silts (average abundance 530 000 ind./m^2, biomass 1.4 g/m^2), while in areas subject to intense impact of river runoff, the nematofauna is poor (average abundance 83 000 ind./m^2, biomass 0.2 g/m^2) (Kulakova, 2006, Vorobyova and Kulakova, 1998). The preferred trophic grouping is non-selective deposit feeders (1B). In low-water years, there is an increase in the density of nematodes compared to high-water years. It was shown that the complexes of the dominant species of the estuarine, fore-delta and seaward parts remain unchanged in all the studied years, which can serve as an indirect confirmation of the presence of natural conditions for such development of nematodes. The ambiguous contribution of individual species to the intracomplex similarity between stations in different years is determined, apparently, by changes in hydrological and hydrochemical conditions characteristic of estuarine water areas, which indirectly affect their development. There is reason to talk about the formed nematode fauna in the study area, which is constantly undergoing quantitative changes under the influence of naturally changing environmental conditions, which is typical for estuarine zones, as well as technogenic load (Kulakova, 2020).

5. CONCLUSION

Features of the Danube delta coastal area affect the functional features of the nematode community. Low biodiversity, an increase in the number of common opportunists, a decrease in the maturity index towards the river mouth, and a predominance of non-selective deposit feeders were recorded. This may indicate unstable hydrological and hydrochemical conditions in this part of the Danube delta coastal area. Low MI values indicate a disturbed/contaminated environment. An increase in ITD values due to the marked dominance of one trophic group (1B) also indicates an increase in stress in the dredging site. The results of the analysis show that the species marked with the greatest contribution to the average intra-complex similarity (S) – indicator species in a particular area simultaneously act as discriminator species, reaching the maximum values of the dissimilarity function (D). For the study areas, species have been identified that can be considered as potential indicators. Thus, in the taxocene of the dredging sites, these are *M. rotundicapitata*, *M. conica*, and *S. pulchra*. In the dumping sites, these are *S. pulchra*, *T. longicaudata*, *S. ostreae*, and *A.* ponticus. In the area of background stations – *S pulchra*, *T. longicaudata* and *A. ponticus*. The results obtained on the ecological status of the Danube delta coastal area using the example of the meiobenthos and nematode communities can help further assess the degree of anthropogenic impact and control the loss of ecosystem functioning.

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