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THE PRELIMINARY BIOLOGICAL ASSESSMENT OF ENVIRONMENTAL QUALITY IN MIDIA HARBOUR - BLACK SEA – ROMANIA

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Midia Harbour is located on the Black Sea coast, about 13.5 km north of the port-city of Constanta. It was designed and built to provide facilities for industrial and petrochemical adjacent activities. In marine harbour areas, the study of benthic populations under the influence of pollution sources provides data regarding the level of pollution in the area depending on the degree of degradation of the biological community; at the same time, it reveals biological data concerning the resistance of various organisms to altered environmental conditions. Taking into consideration the industrial activities in the Midia Harbour area, this study is of particular importance regarding not only pollution-tolerant benthic invertebrates but species richness in general. In order to determine the status of marine water quality inside and in the vicinity of the Midia Harbour, water and sediment samples were collected and subjected to a series of physico-chemical measurements. As a result of biological assessment 14 groups of the following macrozoobenthic groups (Bryozoa, Turbellaria, Polychaeta, Oligochaeta, Bivalvia, Gastropoda, Gammaridae, Cirripedia, Cumacea, Corophiidae, Decapoda, Hydrozoa, Chironomidae larvae, fish - *Gobius sp*.) and two meiobenthic groups (Nematoda and Harpacticoida) were identified and studied. The zoobenthic associations were quite similar within the harbour aquatorium and outside the surrounding area. Most species undergo limits of comparable biological tolerances in the case of high anthropic influence and ecological stress factors. The constant presence of several opportunistic species of polichaetes *Neanthes succinea* and *Polydora cornuta* was noticed, these species being common both in marine harbour environments and in the open sea. Concerning the bivalves *Mytilus galloprovincialis, Mya arenaria, Abra ovata* and *Scapharca inequivalvis* we can say that these species are more resistant to severe environmental conditions, having a better ability to withstand environmental alterations.

Keywords: *Black Sea, Midia Harbour, zoobenthos*

1. INTRODUCTION

In harbour aquatoria, that is areas subjected to considerable anthropic influence, the study of benthic populations enables assessment of the level of pollution in the area according to the degree of degradation of the community in question, also providing ecological data on the resistance of various organisms to altered environmental conditions. Midia Harbour is situated on the Black Sea coastline, about 13.5 km north of Constanta city. It represents one of the satellite harbours of Constanta and it was mainly built for adjacent industrial and petrochemical utilities. The North and South breakwaters have a total length of 6.97 m. The harbour covers 834 ha of which 234 ha is represented by land and 600 ha is water. There are 14 berths (11 operational berths and 3 berths belonging to Constanta Shipyard) with a total length of 2.24 km.

Material and method

This paper presents the results of investigations carried out in August 2011 by The National Institute for Research and Development of Marine Geology and Geoecology – GeoEcoMar as associate beneficiary, together with MED Ingegneria from Italy as part of the project SEDI.PORT.SIL "Recovery of dredged SEDIments of the PORT of Ravenna and SILicon extraction" applied in Midia Harbour. The project's main objective concerns the recycling and usage of dredged harbour sediments with the purpose of turning them from waste into an important source of raw material. Water and sediment samples were collected inside and in the immediate vicinity of Midia Harbour (Fig. 1) for the purposes of determining the main chemical parameters (nutrients, heavy metals, pesticides, aromatic hydrocarbons, etc.) and some biological parameters (zoobethos). Twenty zoobenthos samples were collected with a Van Veen bodengreifer (sampling surface – 0.135 m^2), from depths ranging between 1.9 m and 16.9 m. The usual Black Sea zoobenthos method of analysis was employed for the quantitative and qualitative analysis of the zoobenthic community (Băcescu et al., 1971): washing of the biological material through 0.125 mm granulometric sieves, preservation in 4% formaldehyde and storage in plastic containers and bags, sample triage, species determination and organism count for each species. Biomass was calculated by means of weight tables for Polychaetes and Crustaceans, and bivalves were measured with a view to determining population size categories and subsequently weighed.

Fig. 1 – Sample collecting stations in Midia Harbour, August 2011

2. RESULTS AND DISCUSSIONS

The results obtained were reported in conformity with Normative 161/2006 (Standard on surface water quality classification for determination of the ecological status of Water bodies), Annex C - Elements and physicochemical quality standards in water, and Annex D – Microbiology Quality Elements.

2.1. Physico-chemical parameters

Water pH corresponds to an interval between 8.13 – 8.36. We can state that the pH presents a slightly alkaline character. The ph in station MDA 11-17 was 9.26, a value higher than the values in the other stations, due to algal blooming, maximum euthrophisation. Dissolved oxygen concentrations measured in Midia Harbour aquatorium present values varying from 7.22 to 14.86. Dissolved oxygen saturation fluctuates from 84.7 to 186.1. Conductivity - values determined for electro conductivity are quite high (probably due to the fusion of freshwater with brackish water), alternating from 6.56 to 26.4 (ms/cm) (Table 1).

Table 1 Physico-chemical parameters

Sample	O_2 mg/l	O_2 %	T°C O_2	CND mS/cm	TDS mg/l	E_H (mV)	pH	SS mg/l	Sal ‰
MDA11_01	8,30	98,2	24,2	26,1	131000	153	8,24	11	15,9
MDA11_02	8,81	103,4	23,8	26,4	132000	140	8,19	12	16,2
MDA11_03	8,83	104,4	24,4	26	130000	145	8,24	12	15,9
MDA11_04	7,22	84,7	23,7	25,8	129000	144	8,15	7	15,8
MDA11_05	7,54	88,6	23,9	25,7	129000	158	8,13	5	15,7
MDA11_06	7,60	89,6	24	25,6	128000	135	8,13	6	15,6
MDA11_09	8,62	101,6	24	26,2	131000	145	8,24	5	16
MDA11_10	8,42	99,4	24,1	25,9	130000	137	8,20	5	15,8
MDA11_11	8,36	98,3	23,4	21,8	109000	147	8,30	7	13,1
MDA11_12	8,71	102,6	23,4	20,0	100000	135	8,36	6	12
MDA11_13	8,80	103,2	23,2	19,06	95300	137	8,36	7	11,4
MDA11_17	14,86	186,1	26,8	6,56	32800	156	9,26	102	3,6
MDA11_22	9,02	106,5	23,6	23,7	119000	138	8,36	6	14,3

2.2. Chemical parameters

The test results are reported to nitrogen from nitrates (N-NO3), nitrogen from nitrites (N-NO2) and P total determinations. The results obtained indicate that there was no recorded exceedance of the maximum allowable values for these chemical parameters in any water samples. Sulphates (SO_4^{2-}) – In all the water samples measured the sulphates rise above the maximum allowable content, varying from 215 to 533 mg/l. Overall, we can conclude that the Midia Harbour acquatorium water samples measured correspond to a *good quality status* (in accordance to Normative 161/2006). (Table 2)

Table 2 Chemical parameters

Sample	NO_3^- (mg/l)	NO_2^- (mg/l)	SO_4^{2-} (mg/l)	PO_4^{3-} (mg/l)	$N\text{-}NO_3$ (mg/l)	$N\text{-}NO_2$ (mg/l)	SiO_2
MDA11_01	0,0748	0,0099	495	0,12	0,02	0,003	0,745
MDA11_02	0,0792	0,0396	440	0,38	0,03	0,012	1,144
MDA11_03	0,0704	0,0132	405	0,39	0,02	0,004	0,811
MDA11_04	0,0528	0,0264	365	1,54	0,02	0,008	0,930
MDA11_05	0,1144	0,0132	475	0,35	0,03	0,004	1,019
MDA11_06	0,0176	0,0198	485	0,44	0,01	0,006	0,965
MDA11_09	0,154	0,0165	485	0,07	0,04	0,005	0,875
MDA11_10	0,0044	0,0297	505	0,27	0,01	0,009	0,891
MDA11_11	0,044	0,033	565	0,06	0,02	0,010	0,643
MDA11_12	0,0572	0,0231	485	0,20	0,02	0,007	0,947
MDA11_13	0,0528	0,0264	480	0,20	0,02	0,008	1,049
MDA11_17	0,0308	0,0429	215	0,27	0,02	0,013	6,9
MDA11_22	0,044	0,033	533	0,04	0,02	0,010	0,832

2.3. Organic substance

The percentage distribution of organic matter, carbonates and siliciclastic material in superficial sediments evaluation was done through Loss on Ignition Method (STAS 7107/1-76) based on sequential heating of the sediment samples**.** In what regards the visual macroscopic sedimentology (textural and structural) the superficial sediment samples are related to the class which alternate from very fine-silt and silty clay fractions and rarely sandy accumulations. Every investigated sediment sample show a high percentage of organic matter, a low content of carbonates and the part which remains is represented by siliciclastic fraction (Fig. 2)

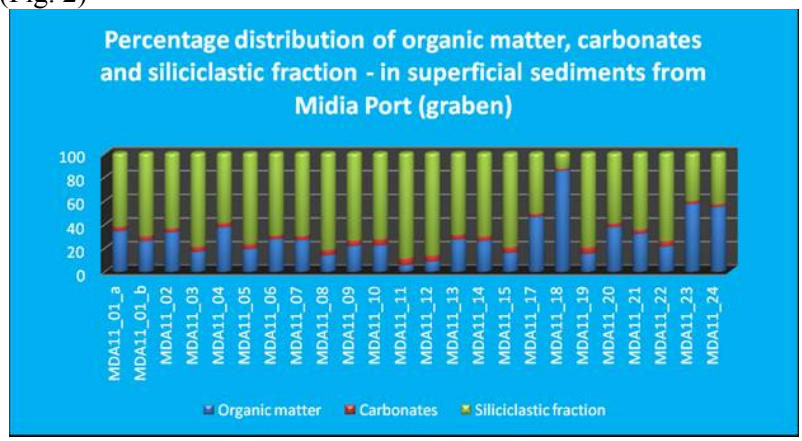

Fig. 2 Percentage distribution of organic matter, carbonates and siliciclastic fraction – in superficial sediments from Midia Harbour

2.4. Macroscopic characteristics of surface sediments

Macroscopic description – done on-board. Most of the collected sediments are muds and silts, rarely fine sands. Muds and silts are generally blackish-grey, more or less cohesive, sometimes with a petroleum product smell. Most contain mica minerals. Fine sands are light grey in colour, rich in mica. Uppermost superficial oxidation layer – variable thickness, with many worm tubes. All sediments contain a significant fraction of heavy minerals (including finer–grained sediments, such as silts). Their source – most probably multiple: Danube born alluvia transported by longshore currents, as well as anthropogenous sources – open storage of dusts and aeolian transport. Sediments from the buffer pool (Refinery Protection Area) - predominantly silty sand with important clay content. Some of them have a strong smell and a significant content (visually observed) of petroleum products in interstitial water and on the sample's upper surface. Finest–grained sediments - near the inland borders of the harbour (N and S breakwaters) – with high contents of aquatic vegetal & animal organisms (many benthic species). Surface sediments not homogeneous in areas with numerous ship manoeuvres (significant daily ship motion generates frequent re-suspension). These sediments have a peculiar structure, without any stratification.

2.5. Macrobenthos

On the basis of structural parameter analysis and density and biomass quantitative indicators recorded for the benthic organism associations in the harbour area it was possible to assess the ecologic state of this biotic component that exists in the aquatorium and the area affected by pollution in the vicinity of the harbour. Sixteen zoobenthic groups were identified following sample processing: Briozoa, Turbelaria, Polychaeta, Oligochaeta, Bivalvia, Gasteropoda, Gammaridae, Cirripedia, Cumacea, Corophiidae, Decapoda, Hydrozoa, Chironomidae larvae, Nematoda, Harpacticida, fish – *Gobius sp*. Benthic populations in the harbour area had an average density of 21659 ind.m^{-2} and an average biomass of 342.9 g.m^{-2} (Tab. 3). The qualitative structure of benthic fauna was characterised by the dominance in terms of frequency (F%:100) of Polychaetes and Nematodes, known as indicator species for water pollution or high organic content, proliferating with increased marine environment eutrophisation.

Table 3. – General average values of parameters characterising populations of benthic organisms in the Midia sector

No.	Species	F%	Davg ind/m²	DD%	RkD	Bavg g/m²	BD%	RkB
1	Bryozoans	25	0.0	0.000	24	0.000	0.0000	24
2	Turbellaria	50	35	0.163	8	0.001	0.0002	20
3	Nematodes	100	16999	78.486	**1**	0.030	0.0086	12
4	Polychaetes	100	1522	7.028	**2**	0.061	0.0178	11
5	Oligochaetes	50	416	1.920	**5**	0.008	0.0024	16
6	*Abra ovata*	50	641	2.959	**4**	89.089	25.9813	**2**
7	*Mya arenaria*	50	32	0.148	**10**	19.491	5.6842	**6**
8	*Cardium edule*	63	54	0.251	**7**	114.187	33.3006	**1**
9	*Scapharca inequivalvis*	38	35	0.160	12	28.836	8.4095	**5**
10	*Mytilus galloprovincialis*	50	28	0.127	11	12.914	3.7661	**7**
11	*Mytilaster lineatus*	25	4	0.021	19	1.335	0.3893	10
12	*Hydrobia sp.*	38	17	0.077	16	0.029	0.0084	15
13	*Cylichnina variabilis*	13	2	0.008	22	0.001	0.0001	22
14	*Bittium reticulatum*	13	13	0.058	18	0.009	0.0026	17
15	*Ampelisca diadema*	38	21	0.099	14	0.001	0.0004	19
16	*Balanus improvisus*	38	30	0.140	13	39.338	11.4722	**3**
17	Cumaceans	13	3	0.012	20	0.001	0.0003	21
18	Corophidae	25	231	1.064	**6**	0.092	0.0269	14
19	Decapoda	63	27	0.123	**9**	6.648	1.9389	**8**
20	Harpacticoids	88	1519	7.014	**3**	0.030	0.0089	13
21	Hydrozoa	50	16	0.072	15	25.365	7.3973	**4**
22	Chironomidae larvae	38	11	0.049	17	0.002	0.0006	18
23	Chironomidae pupae	13	3	0.012	21	0.000	0.0001	23
24	*Gobius* sp.	13	2	0.008	23	5.429	1.5833	**9**
			Davg	**DD%**		**Bavg**	**BD%**	
	Worms		18972	87.60		0.10	0.03	
	Molluscs		825	3.81		265.89	77.54	
	Crustaceans		1831	8.45		46.11	13.45	
	Miscellaneous		31	0.14		30.80	8.98	
	TOTAL		**21659**	**100**		**342,9**	**100**	

The polychaete worm fauna, which represents a main component of the coenosis under discussion, consists of species with wide ecological valence (opportunistic polychaetes, resistant to less favourable environmental conditions - (*Neanthes succinea, Polydora cornuta, Capitella capitata*)(Nicolaev S., Patrascu V., 2008) In the area studied, the worm group was dominant in terms of density (87.6% of the total) (Fig.3). The tubicular amphipod *Ampelisca diadema*, a species with a wide ecological valence, less sensitive to marine environment quality changes, was numerically dominant within the crustacean fauna. The mollusc group was represented by six bivalve species, *Mytilus galloprovincialis, Cardium edule, Abra ovata, Mytilaster lineatus, Scapharca inequivalvis si Mya arenaria* – the last two of which are opportunistic

species, resistant to more severe environmental conditions. Ponderally, bivalves represent over 77.5% of total average biomass. (Fig. 4)

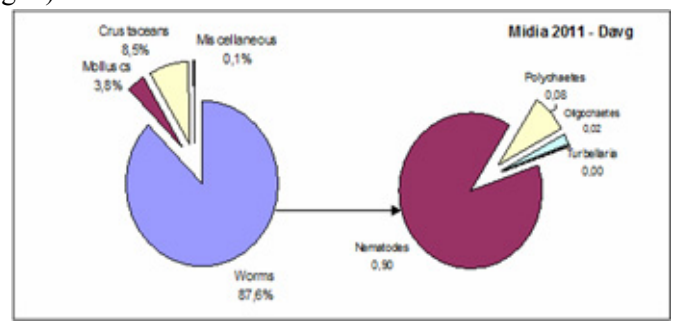

Fig. 3 – The general taxonomic structure of zoobenthic populations in terms of density

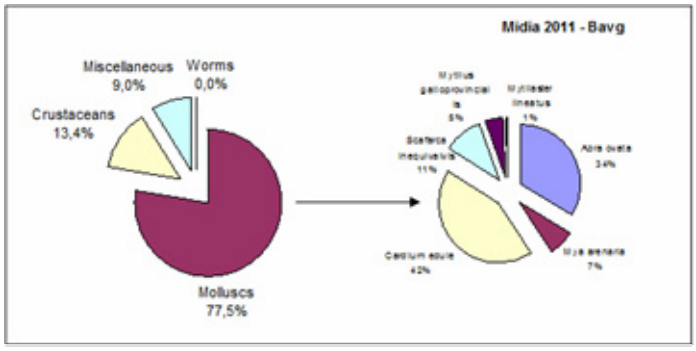

Fig. 4– The general taxonomic structure of zoobenthic populations in terms of biomass

The high frequency and numeric dominance of worm populations found in numerous types of biocoenoses represent a consequence of increased anthropic pressure on the marine environment (Tab.3). In recent times, following the mass mortality of benthic organisms caused by hypoxia and anoxia phenomena, there has been a massive development of endobenthic detritophages, especially Oligochaeta and some Polychaeta species (*Capitella capitata, Polydora cornuta*), and a diminution in the total numbers of individuals belonging to epibenthic species (crustaceans, some molluscs). Increased populations among these groups of organisms result in diminishing biomasses and, as a consequence, in an impoverished trophic base in the case of benthofagic fish (Begun T. et al 2009) (Fig.5).

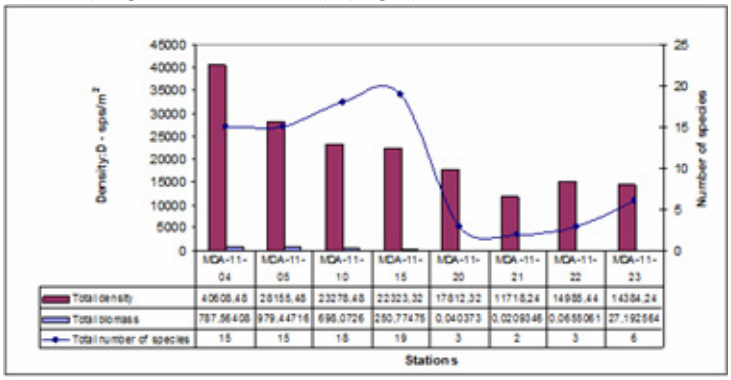

Fig. 5 The variation of densities, biomasses and number of taxa in the Midia sector in 2011

The most spectacular development in terms of population is that of the polychaete *Polydora cornuta*. It is an opportunistic species, present on the Romanian littoral on various types of sediment substrates. It frequently is the dominant species, especially in areas with high organic content in sediments or in polluted areas. *Polydora cornuta* builds tubes out of sand particles bound with fine pelitic fractions which are vertically disposed across the width of the sediment. The species prefers the eutrophic waters rich in detritus and biogenic elements of estuaries, being able to withstand low salinities (Blake, 1996). In the north-western region of the Black Sea this polychaete was found at salinities ranging from 6.4‰ to 17.9‰ (Losovskaya, 1977; Surugiu and Zamfirescu, 2004). In some cases this polychaete was found in the bottom areas heavily polluted by petroleum products. (Losovskaya, 1976). In the samples collected in Midia Harbour, the average density recorded for the polychaete *Polydora cornuta* is 725.46 individuals m^2 in the sluice area (MDA-11-

23, MDA-11-22, MDA-11-21, MDA-11-20) where water salinity is 14.3‰ (Tab.1). Analysis of the data obtained taking into account the type of sediments encountered in the area under analysis indicates the fact that the highest quantitative and qualitative values for benthic fauna were recorded on blackish-grey mud or unctuous silt bottoms. At present, research is directed at identifying the benthic indicators specific for each type of biocoenosis/association, so that the state of the ecosystem can be best reflected. In the future it is essential to take into account aspects related to the status of dominant species which mask the real situation of the ecosystem, as is the case of opportunistic and exotic species.

3. CONCLUSIONS

- The specific environmental indicators investigated in Midia Harbour aquatorium are generally below the maximum allowable limits in conformity with standards and regulations, with the exception of some heavy metals (As, Ba, Se) and sulphates. (*Good quality status* or *Moderate quality status)*
- *Grain size:* The entire sediment mass is represented mainly by silts, secondary fractions of very fine sands and clays being present. Wider grain fragments are represented by shell fragments.
- *Mineralogy:* the sandy fraction is made up of varying percents of quartz, heavy minerals and other minerals (feldspar, mica chlorites etc.). Carbonaceous minerals are present – their source being the mollusc shells.
- *Chemical pollution:* most parameters did not show high values for heavy metals (*Good quality status* or *Moderate quality status)*. Instead, organic pollutants (PAH's and PCB's) exceeded the maximum allowable limits in almost all samples (*Low quality status)*
- The ensemble of existing species in the harbour aquatorium cannot be considered an individualised biocoenosis or a community, as these species also appear in biocoenoses situated outside harbour perimeters. Their coexistence in this marine environment is only due to the fact that the species in question have similar tolerance limits and there are in general no significant biological interactions between them.
- Analyses highlighted the constant presence of the opportunistic polychaetes *N. succinea* si *P. Cornuta*, species characterised by very high resistance to pollution, present both in the marine environment inside the harbour perimeter and in the open sea, as well as of the bivalves *Mytilus galloprovincialis, Mya arenaria*, *Abra ovata si Scapharca inequivalvis* whose populations are more resistant to severe environmental conditions, being capable of successfully withstanding decreasing quantities of dissolved oxygen.
- In the sluice area (MDA-11-23, MDA-11-22, MDA-11-21, MDA-11-20), as a result of the higher ratio of fresh water, there was a lower number of macrobenthic species, as well as lower densities and biomasses.

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