ASSESSMENT OF THE NUTRIENT LOADS RECEIVED BY THERMAIKOS GULF, N.W. AEGEAN SEA

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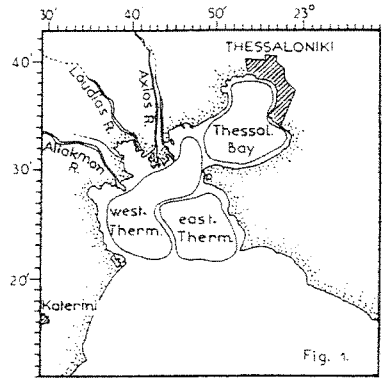
Thermaikos Gulf, a shallow (max depth 40 m) semi-enclosed water embayment in the Northwestern Aegean Sea, is of particular environmental interest for both scientists and authorities. It is exposed to the domestic wastes of the city of Thessaloniki (approx. 1,200,000 inhab.) as well as the industrial effluents of the nearby industrial zone. Moreover the estuaries of three rivers Axios, Loudias and Aliakmon are influencing the hydrological regime of the area. Previous oceanographic studies concerning eutrophication conditions of the Gulf were carried out during the years 1975-76 and 1985-86. The aim of this study is to investigate the present eutrophication conditions and to compare them with those of the previous studies. Water samples were collected during four cruises from September 1992 to August 1993 at standard depths in 19 stations. The methodology used was the same as in the 1975-1976 study. The Gulf was divided into three water masses (subareas) : the Thessaloniki bay (A), the Western (B) and the Eastern (C) gulf (BALOPOULOS, 1985). The sampling stations as well as the above mentioned subareas are shown in Figure 1. Table 1 shows the integrated mean values of nutrients and the ΣN/P ratio at the four cruises. It also gives the mean value of every constituent in each subarea. The relatively higher concentrations especially of PO_4 but also of NH_4 and NO_3 are measured in Thessaloniki bay, while NO_2 and SiO_4 values are relatively low.



Area	Sampling	PO_4-P	SiO_4-Si	NH_4-N	NO_2-N	NO_3-N	ΣN/P
	9/1992	0.10	0.92	0.16	0.05	0.06	3.66
Thessaloniki	1/1993	0.54	1.02	0.93	0.32	1.22	3.95
Bay	4/1993	0.63	0.99	0.51	0.09	0.50	1.85
	8/1993	0.34	0.67	0.69	0.09	0.43	6.10
	Mean	0.40	0.90	0.57	0.14	0.55	3.89
	9/1992	0.06	1.11	0.16	0.04	0.12	5.89
Western	1/1993	0.24	0.64	0.41	0.25	0.75	5.92
Thermaikos	4/1993	0.18	1.03	0.22	0.04	0.34	3.13
	8/1993	0.09	0.76	0.14	0.06	0.18	6.01
	Mean	0.14	0.89	0.23	0.10	0.35	5.24
	9/1992	0.07	1.42	0.20	0.10	0.20	5.87
Eastern	1/1993	0.18	0.59	0.36	0.26	0.55	6.37
Thermaikos	4/1993	0.11	0.76	0.18	0.03	0.19	3.58
	8/1993	0.06	0.56	0.18	0.07	0.32	9.52
	Mean	0.11	0.83	0.23	0.12	0.32	6.34

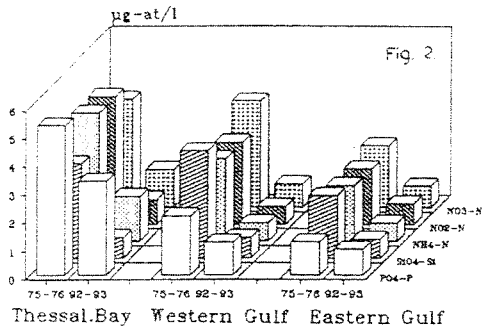
Table 1. Integrated mean values of nutrients (µg-at/l) of the three subareas.

These high concentrations are due to the untreated wastes that are discharged into the bay near the city of Thessaloniki through the central sewage outfall. Moreover the mean values of the three subareas are multiplied with the volume of the water masses to calculate the total amount of nutrient loads in g-at.10^6. These amounts are divided by the reference amounts for the same volume of the water masses (concentrations characterizing the oligotrophic Aegean waters (FRILIGOS, 1981) multiplied with the volume of the three water masses) to give the degree of eutrophication of each subarea (Table 2).

Table 2. Eutrophication degree of the three subareas.

Area	PO4-P	SiO4-Si	NH4-N	NO2-N	NO3-N
Thessaloniki bay	3.33	0.74	1.59	0.88	1.31
Western Thermaikos	1.17	0.73	0.64	0.63	0.83
Eastern Thermaikos	0.93	0.68	0.64	0.74	0.76

The present eutrophication conditions are compared with those of the 1975-76 study (FRILIGOS, 1990) in Figure 2. It is obvious, from Figure 2, that the present conditions are better than those which existed about twenty years ago. This must be due to the reduction of the load of the wastes after the operation of the Sewage Treatment Plant. Also the diminution of the rainfalls has as a consequence the decrease of the nutrients originating from the fertilizers used for agricultural purposes at the surrounding areas. The results reported in this study can be used as reference values in the future when the Treatment Plant will be in full operation.



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TRACE METALS IN THE SHELL OF THE MEDITERRANEAN MUSSEL *MYTILUS GALLOPROVINCIALIS*

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Marine bivalves are known to accumulate high levels of metals in their tissues and are commonly used in biomonitoring studies. An alternative approach to the analysis of metals in soft tissues may be the use of shell which would allow also the comparison with fossil samples. However, since the processes regulating metal accumulation in the shell remain still unclear, further research is needed to validate the use of this structure in monitoring programs.

The aim of this work was a preliminary characterization of trace metal levels in the shell of the Mediterranean mussel *Mytilus galloprovincialis*, the distribution of these elements among the various mineralogical components and the influence of organism size on metal levels in the shell.

Mussels were collected respectively from a clean and a trace metal polluted area of North Tyrrhenian Sea; after removing soft tissues, the shells were cleaned with a nylon brush and dried at 45°C until constant weight. Metals were determined in whole shells, in shells without the periostracum and in the calcite and aragonite phases. Periostracum was removed by solubilization in 20% Tetramethylammonium hydroxide (TMAH) at 60°C for 3 h; calcite and aragonite components were separated (after a preliminary treatment with TMAH) at 400°C for 1 h. Samples were digested with concentrated nitric acid and metals determined by atomic absorption spectrophotometry. The standard addition method was used to eliminate matrix effects. The influence of organism size on trace metal concentrations was assessed in mussels from both the populations by analysing whole shells of different size classes.

Metal concentrations in the shell of mussels from Scarlino (polluted site) and La Spezia (clean site) are reported in Table 1. Previous studies on trace metal concentrations in soft tissues of mussels from both the populations indicated, for Scarlino, high environmental levels especially of Mn, Pb and Fe (REGOLI, 1992; REGOLi and ORLANDO, 1993, 1994a,b).

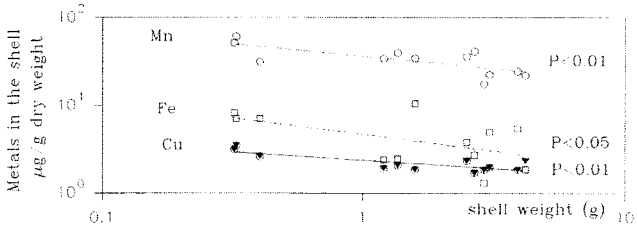
These findings were partially confirmed by data on shell analysis which showed higher concentrations of Mn and especially of Pb in mussels from Scarlino. On the other hand, no statistical difference was observed for Fe in whole shells of mussels from the two populations. This fact could be explained hypothesizing that iron, mainly present in seawater as oxide-hydroxide compounds, cannot be secreted, in this chemical form, into the extrapalleal fluid. Similar values of Cu and Zn in whole shells of mussels from both the populations agree with data previously reported for soft tissues.

The removal of periostracum generally reduced the concentrations of metals (with some exceptions) indicating an important contribution of this component to the total metal burden in the shell. The distribution of metals in calcite and aragonite differed according to the element, but was rather similar in mussels from the two populations.

Table 1. Trace metal concentrations (g/g dry weight)) in different mineralogical components of shell in *Mytilus galloprovincialis* from a polluted (Scarlino) and a clean (La Spezia) site. (Mean values standard deviations, n=5)

Metal	Site	Whole shells	Shells without periostracum	Calcite	Aragonite
Mn	Scarlino	27.0±8.66	15.1±2.92	11.4±5.72	1.84±0.97
	La Spezia	6.08±2.25	5.58±2.22	7.66±1.99	1.13±0.53
Fe	Scarlino	3.58±1.65	0.78±0.45	1.19±0.99	2.39±1.47
	La Spezia	2.30±1.35	0.24±0.39	1.01±0.67	4.89±4.55
Pb	Scarlino	16.6±4.04	16.4±3.80	15.5±2.74	9.77±2.26
	La Spezia	< 0.5	< 0.5	< 0.5	< 0.5
Cu	Scarlino	1.44±0.39	0.40±0.05	0.79±0.16	0.63±0.26
	La Spezia	1.50±0.17	0.38±0.09	0.61±0.21	0.85±0.57
Zn	Scarlino	0.94±0.63	0.58±0.12	0.60±0.19	0.74±0.20
	La Spezia	0.55±0.08	0.19±0.12	0.43±0.14	0.62±0.36

The influence of size on metal concentrations in whole shell resulted significant only for Mn, Fe, Cu and Zn in mussels from the polluted site (Figure 1).



From data reported in the present study, trace metal concentrations in shells seem to reflect the bioavailability of these elements in the environment, even though the variability of the results is generally higher than with the analysis of soft tissues. Shell could represent an useful tool in biomonitoring studies especially when soft tissues are not available.

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