GEOCHEMICAL ASPECTS OF A GULF INFLUENCED BY ANTHROPOGENIC ACTIVITIES (THERMAIKOS GULF, N.W. AEGEAN SEA)

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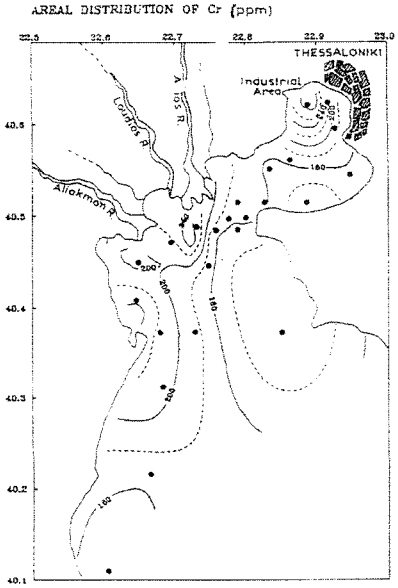
Thermaikos Gulf, in the N.W. Aegean Sea, receives about 120,000 m^3/day of untreated sewage water from the city of Thessaloniki, with a population of 1,200,000 inhabitants. Also, an amount of about 25,000 m^3/day of treated or partially treated industrial effluents is released on the northwestern coast of the bay, where the industrial zone is located. On the west side of Thermaikos Gulf, the rivers Axios, Loudias and Aliakmon release important amounts of some metals to the sea. The main interest of the present study is to assess the environmental state of the region, as far as the heavy metal levels is concerned, after the removal of the 30% of the sewage discharges via the newly constructed outfall. It is also to compare the status of the marine environment 20 years after the first investigations.



Surface sediment samples recovered from Thermaikos Gulf during 1993 over a grid of 24 stations were examined for grain composition, organic carbon and the metals Fe, Cr, Ni, Mn, Zn Co, Cu and Pb. The samples were taken using a 0.1m^2 van Veen grab. The extraction of the metals was achieved with 2N HCl and the determination of the metal content in the leachates was performed on a Perkin-Elmer 305B A. A. S. (SATSMADJIS & VOUTSINOU-TALIADOURI, 1981). The particle size composition was estimated according to BUCHANAN's technique (1971). The organic carbon was obtained according to GAUDETTE *et al.*, 1974. Analyses were performed in triplicate. The reliability of the whole process had been ascertained in Intercalibration Exercises (I.A.E.A., 1978). The analyses indicated the following average standard deviations and coefficient of variations : Fe (‰) 0.85, 4.4; Mn (mg/kg) 38, 5.0; Zn (mg/kg) 4.3, 7.2; Cr (mg/kg) 3.8, 3.4; Ni (mg/kg) 3.3, 4.1; Co (mg/kg) 0.9, 8.2; Cu (mg/kg) 1.1, 4.8; Pb (mg/kg) 0.8, 6.7.

The cold dilute HCl extraction method is chosen because it will release both inorganic and organic associated non-residual heavy metals from sediments without materially affecting the silicate matrix (DUINKER *et al.*, 1974). The analysis of the non-residual (non-lattice held) elements will often yield more data on the extent of heavy metal pollution than will that of the total sediment which include the residual or non-polluted fraction. Non-residual heavy metals are not part of the silicate matrix and have been incorporated into the sediment from aqueous solution by processes such as adsorption and organic complexation, i.e. non-residual heavy metals include those originating from polluted waters (CHESTER & VOUTSINOU, 1981). The analyses of the data reveals that most of the Thermaikos Gulf seafloor is covered by fine sediment, which is derived mainly from the Rivers Axios, Loudias and Aliakmon and containing relatively high amounts of heavy metals. The elements studied can be divided into two categories : the ones derived mainly from anthropogenic activities and the others which are probably depended on natural geochemical processes. More specifically, the main sources of organic carbon and Cu, Pb, Zn, Cr (Fig. 1) are the Thessaloniki sewage and industrial outfalls and the Axios river. Nickel, Co, Fe and Mn have mostly a natural origin, being derived from the weathering of mafic and ultra-mafic rocks, largely extended on the adjacent land (VOUTSINOU-TALIADOURI & VARNAVAS, in press).

Table 1: Heavy metal concentrations of the present study, together with those reported in the past (10 and 20 years ago).

	Fe %	Cr ppm	Ni ppm	Mn ppm	Zn ppm	Co ppm	Cu ppm	Pb ppm
Present Study	1.94-3.14	121-294	60-224	463-1935	73-203	13-30	17-51	20-150
Study of '85*	-	66-390	55-290	215-1340	32-1610	14-37	8-170	11-330
Study of '75**	-	102-353	52-240	347-2050	45-280	12-42	11-82	13-230

** VOUTSINOU-TALIADOURI, F. & LEONDARIS, S.N.*
*** CHESTER, R. & VOUTSINOU, F.G. After the modification with a factor which equilibrates the two extraction techniques.*

Table 1 gives the results obtained from this study, as well as results obtained with the same methodology 10 and 20 years ago. As it can be seen, the heavy metal ranges do not have changed during the 20 last years. The relatively higher maximum values of the non-residual heavy metals (Cr, Zn, Cu and Pb) observed in the study of '85 are mainly due to the fact that the sampling stations in that study were closer to the pollution sources.

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ACCUMULATION OF SOME HEAVY METALS IN MARINE POLYCHAETE (*EUNICE APHRODITOIS*) AND SEDIMENTS OF THE ADRIATIC COAST

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This paper reports on levels of heavy metals in some marine polychaete (*Eunice aphroditois*) and surrounding sediments from eastern Adriatic coast. Different parts of worms (head, skin and muscle) were examined. Samples were collected at 8 stations in the vicinity of urban centers (Split and Sibenik) where considerable quantities of untreated effluents are discharged and affect significantly the quality of marine ecosystem.

Heavy metals were determined using a double beam AAS, applying a flameless spectrometry. Polychaetes are among the most frequent and abundant marine metazoans in benthic environment. They live in bathyal and abyssal areas, in shelf depths and open coasts in estuaries and in man–made harbours. Today the number of known Eunicadea is about 241 species (FAUCHALD, 1979).

Metal		Head	Skin	Muscle	Sediment	Correlation
Mn	R rsd	0.84-4.73 (2.58)	0.73-6.16 (3.22)	0.41-1.58 (2.25)	99.2-377.9 (0.56)	No
Cr	R rsd	0.49-1.44 (2.21)	0.73-2.29 (4.02)	0.35-1.16 (1.68)	23.6-65.0 (5.27)	No
Ni	R rsd	0.20-0.82 (4.02)	0.31-1.12 (3.05)	0.23-1.17 (1.7)	4.10-14.0 (3.06)	Yes
Pb	R rsd	1.28-37.4 (2.04)	4.00-30.1 (1.26)	2.30-24.9 (1.65)	11.2-67.7 (2.35)	Yes
Cu	R rsd	1.95-11.28 (1.50)	1.70-4.35 (1.31)	0.91-1.68 (1.50)	3.84-11.79 (1.18)	No
Cd	R rsd	0.08-0.29 (2.08)	0.11-0.54 (2.31)	0.14-0.87 (1.77)	0.14-0.74 (7.20)	No
Zn	R rsd	4.46-6.08 (0.95)	6.26-11.87 (0.62)	4.83-8.33 (1.07)	12.92-40.96 (7.40)	No

Table 1. Range of mass concentrations (W_m x 10^6) of heavy metals polychaetes and sediments on investigated areas. (Values in parenthesis are relative standard deviations – rsd).

Despite their obvious importance the literature on ecological roles of these polychaetes, the information about their feeding and biology remains largerly anecdotal. *Eunice aphroditois* is mainly a carnivore. EVANS (1971) found its gut content included annelids, chaetognaths ostracods, copepods, bivalves, a few diatoms and some detritus.

The preliminary results of trace metal concentrations in these worms showed that some of the studied metals are accumulated mainly in head or in skin (Al, Cr, Pb and Cu), whereas others are accumulated in muscle (Zn, Ni).

In our investigation of trace metals in polychaetes and surrounding sediments, where these worms live, we didn't find significant correlations, except for Pb and Ni.

Probably the reason for that is the manner of feeding. This worm is primarily a carnivore, feeding on all kinds of small invertebrates. Spatial distribution of some heavy metal values showed that higher values were recorded in stations with smaller depth or in stations which were situated in an unclosed area (Sibenik). This could be attributed to anthropogenic effects, i.e. to land–based activities.

It is recommended to continue the monitoring of heavy metals concentration in these organisms in order to improve our understanding of their cycling in the marine environment.

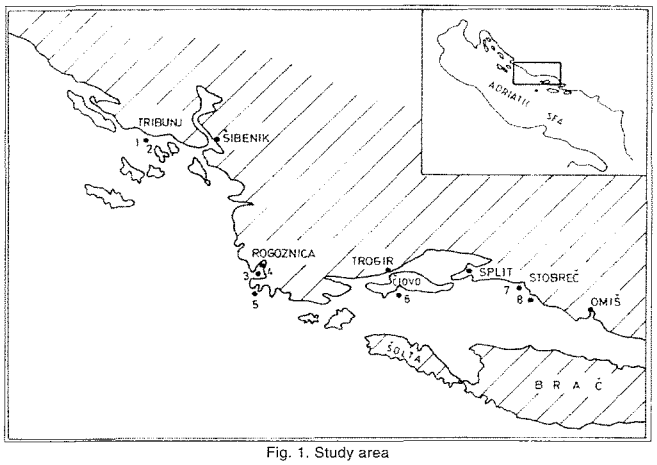

Fig. 1. Study area

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