

HORIZONTAL AND VERTICAL DISTRIBUTION OF HEAVY METALS IN SEDIMENTS FROM THERMAIKOS GULF

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Abstract

The area under investigation is the inner part of Thermaikos Gulf which is comprised of Thessaloniki Bay and Thessaloniki Gulf. For several years this marine region has been accepting domestic and industrial discharges of Thessaloniki, thereby loading the ecosystem with several pollutants. A set of surface sediments and core samples from Thessaloniki Bay and Thessaloniki Gulf have been analysed for sedimentological properties, heavy metals and organic load. All analyses revealed that Thessaloniki Bay is the most polluted area of the inner gulf. The color of the polluted surface sediments was dark gray to black and the concentrations for Zn, Cu, Pb, Cd and the organic carbon content were higher than in the outer Thessaloniki Gulf. An examination of the vertical distribution for the same metals and organic load showed a significant increase of pollutants towards the upper layer of the sediment column forming a "polluted layer". The extent of this layer was calculated at about 25 km² and its volume at approximately 4.42x10⁶ m³.

Keywords: pollution, metals, sediments, Aegean Sea

Introduction

The area under investigation includes the bay and the gulf of Thessaloniki, both of which comprise the inner Thermaikos Gulf. The southern border of the area is defined by the present outfall of the Axios river and the cape Megalo Emvolo (Fig. 1). Thessaloniki Bay, which extends northward of the line defined by the old outfall of Axios river (Paliomana) and Cape Mikro Emvolo, is a shallow embayment with a maximum depth of 19 m. The gulf of Thessaloniki is a wider marine area with a maximum depth of 29 m. The major characteristic of both areas is the very shallow zone across the western coast, which is a result of the Axios river sediment supply. In the last few decades the domestic and industrial wastes of Thessaloniki were totally discharged in the marine area under investigation. This anthropogenic influence caused certain changes of the seabed properties and also ecosystem disturbance.

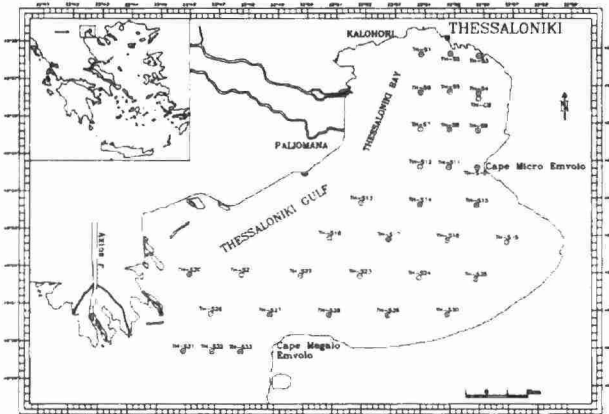


Fig. 1. Location of the area under investigation. Surface sediment sampling stations TH-S1 / TH-S33 and core station TH-C8.

The aim of this study is to describe the present situation of the seabed, to determine the horizontal and the vertical distribution of the anthropogenic polluted layer and, finally, to obtain data on the organic load and heavy metal content of this layer.

Materials and methods

Sediment sampling in the bay and the gulf of Thessaloniki was carried out during three cruises of R/V *Aegaeo* in 1995 (Fig. 1). Thirty three surface samples were collected with a McIntyre grab. In addition nine gravity cores were collected. In order to estimate the extent and the thickness of the polluted layer, 154 cores were taken using a square cross section stainless steel corer especially designed for this purpose [1]. The samples were analyzed for grain size (Sedigraph Micromeritics 5100), mineralogy (XRay-Diffractometer Rigaku D/Max B) and carbonate content [2], and for the heavy metals Zn, Cu, Ni, Cr, Pb, Cd, Fe, Mn and Al (Atomic Absorption Spectrophotometer Varian SpectrAA) and organic carbon content [3] in the $\phi < 63\mu\text{m}$ fraction. For the total dilution of the sediments, the samples were successively attacked with concentrated nitric acid, hydrofluoric acid, aqua regia and perchloric acid in teflon bombs [4]. The analytical procedure was tested by analysing simultaneously the reference sediment SD-M-2/TM IAEA - Monaco, No 182.

Results

The sediments of the seafloor and the seabed of the bay and the gulf of Thessaloniki are homogeneous in terms of their grain size properties and

are represented mainly by mud, sandy mud and sandy clay. This sedimentary facies is characteristic of the deltaic system of the area, showing relatively high sedimentation rates.

The input of domestic and industrial discharges in the area has affected the sedimentation processes. The continuous accumulation of anthropogenic by-products on the seafloor is still disturbing the sediment composition in terms of the organic load and metal content. The increase of the organic load in the sediments, which is caused by oxygen depletion at the sediment-water interface, gives them their characteristic gray black to black color. According to this feature, the extent and the thickness of the so called "polluted layer" was mapped. Figure 2 illustrates that the polluted area is the Thessaloniki Bay extending from the Cape Mikro Emvolo to the port establishments and the Kalohori inlet.

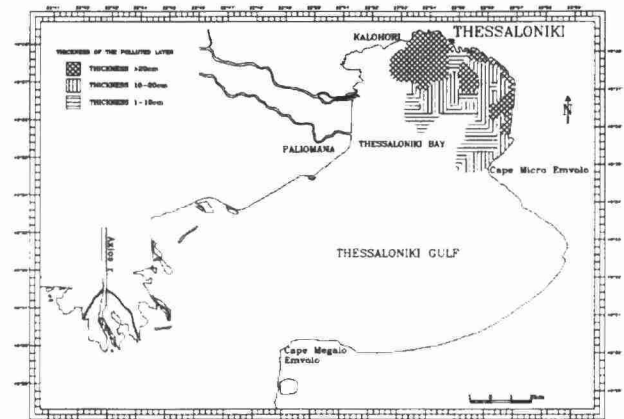


Fig. 2. Extent and thickness of the "polluted layer".

The thickness of the anthropogenic "polluted layer" varies between 1 cm in the south part of the bay, and 65 cm near the oil transport settlements of Kalohori inlet. The seafloor area covered by the "polluted layer" was calculated to be about 25 km² and its volume 4.42x10⁶ m³. The dark colored "polluted layer", which is usually poor in benthic organisms and sometimes azoic, lies above deposits rich in coral skeletons of the genus *Cladocora* and other benthic organisms [1]. These deposits are evidence of the natural unpolluted environmental conditions which dominated in the area in the near past. Furthermore, this sub-surface layer can be used as an indicator of ecosystem remediation when the anthropogenic inputs are reduced or cease.

Table 1. Summary statistics for Thermaikos Bay and Thermaikos Gulf geochemical analyses.

	Zn	Cu	Ni	Cr	Pb	Cd	Mn	Fe	Al	Corg
	ppm									
	%									
Thermaikos Bay (n=12)										
Average	296	79	95	221	64	1,33	826	4,78	9,26	2,30
Minimum	193	57	76	196	46	0,55	535	3,33	8,09	1,69
Maximum	549	162	115	265	113	4,59	1322	5,54	15,61	3,39
Thermaikos Gulf (n=21)										
Average	158	43	106	190	41	0,44	1039	4,86	8,15	1,45
Minimum	105	35	93	151	30	0,19	557	3,71	6,47	0,94
Maximum	194	49	117	214	47	1,36	1515	6,29	9,09	2,05