STUDY OF THE ORIGIN OF CERTAIN METALS IN SURFACE SEDIMENTS OF PAGASSITIKOS GULF, AEGEAN SEA

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Abstract
Major and trace elements were determined in the surface sediments of Pagassitikos Gulf, Greece. Higher concentrations of the anthropogenic metals (Cu, Zn, Pb, As, Cd and Hg) were found near Volos port, whereas the unusually elevated Ni and Cr concentrations were attributed to rock weathering. The significantly high Mn concentrations determined in the eastern gulf, according to previous studies, were attributed to authigenic manganese formations.
Keywords : Aegean Sea, Eastern Mediterranean, Pollution, Sediments, Trace Elements.

Introduction
Pagassitikos Gulf is a semi-enclosed bay covering approximately 520 km^2. It is connected to the open Aegean Sea through Trikeri Channel (5.5 km wide and 82 m deep). Small streams and rivers discharge mainly into its western part. The city of Volos (population more than 100,000) and its port are located in the northern part of the gulf. The industrial zone of Volos is well developed, while the Volos Wastewater Treatment Plant (VWTP) operates since 1985, whereas, since 1992, industrial and domestic wastes undergo chemical and biological treatment. The present study is a part of the ongoing MED POL Monitoring Project and aims at investigating possible changes in the quality of the surface sediments of the gulf compared to previous studies.

Materials and Methods
Major and trace elements, $CaCO_3$ and C organic were determined in the <63Îijm grain size fraction of the surface sediments collected from seven stations in Pagassitikos gulf [Fig. 1]. For the major and trace element analysis the X-ray Fluorescence (XRF) technique was used [1]. Cadmium and Hg were determined by Graphite Furnace AAS and Cold Vapor AAS, respectively, after total dissolution of the sediment samples. Organic carbon and carbonate content were determined using a CHN elemental analyzer type EA-1108, following published procedures [2].

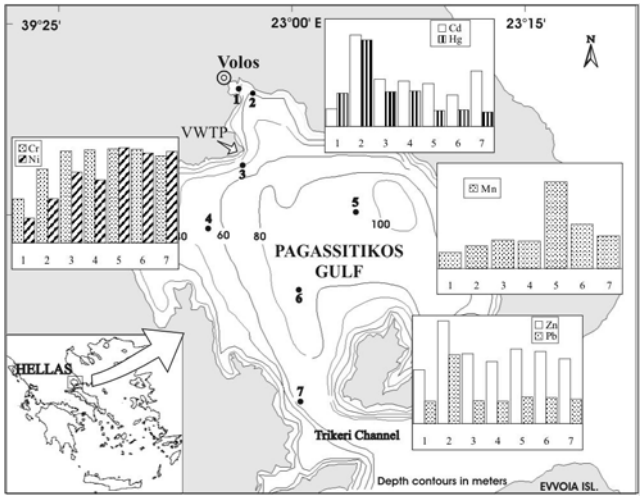

Fig. 1. Map of the study area and the sampling stations. The distributions of some element concentrations in the different stations are also shown on the map.

Results and Discussion
Element concentrations ranged as follows: Corg 0.67-1.11 %; S 0.069-0.459 %; Cu 25.3-60.6 ppm; Zn 89.5-171 ppm; Pb 37.1-114 ppm; Cd 0.129-0.681 ppb; Hg 0.106-0.643 ppb; Cr 125-267 ppm; Ni 70-270 ppm; Mn 520-2879 ppm; Fe 4.36-5.44 %; Al 6.68-9.74%. The distribution of representative elements is shown schematically on the map [Fig. 1]. Station 2 is found the most enriched in anthropogenic metals (Cu, Zn, Pb, As, Cd and Hg) as well as in organic C and S. Station 1, located also in the port, is not equally polluted due to the coarse character of its surface sediment. The elevated concentrations of Mn in Stations 5 and 6 (more than 2000 ppm) are attributed to diagenetic formation of manganese carbonates, a phenomenon described in previous studies [3]. The unusually high concentrations of Ni and Cr were not identified in areas directly influenced by anthropogenic activities. They were determined in the deeper stations and so they are attributed to the weathering of ultra-basic peridotites and ophiolites present in the Pilio mountain catchment area [4]. Correlations between the geochemical parameters showed mainly the terrigenous origin of Ni and Cr, whereas the remaining heavy metals (Cu, Zn, Pb, As, Cd and Hg) are strongly correlated to C and S and thus directly related to pollution sources [Fig. 2].

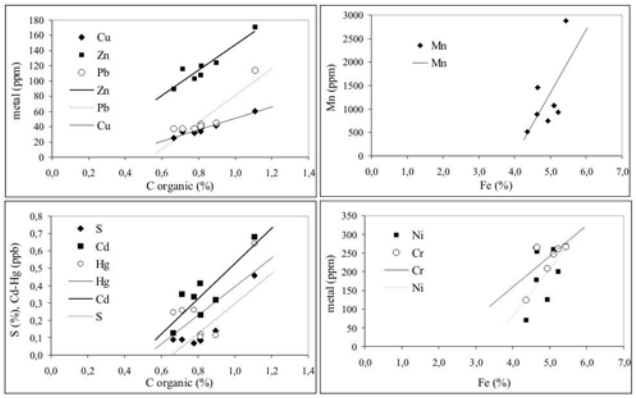

Fig. 2. Linear correlations between the different elements.

Direct comparison with previous studies in Pagassitikos Gulf is not feasible, since they were conducted neither on the same grain size fraction of the sediments [3] nor using the same analytical methods [5]. However, all studies showed that anthropogenic metal concentrations were significantly higher in the northern part of the gulf, except Cr and Ni that were found increased mostly in the deeper sediments. The anomalously elevated Mn concentrations in the eastern part of the gulf, determined in this study, were also found in the past and explained in detail [3]. All these findings lead to the conclusion that anthropogenic activities concentrated in the port and the city of Volos constitute the major pollution source in the area.

References

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