EVALUATION OF METAL POLLUTION IN THE COASTAL SEDIMENTS OF LESVOS ISLAND, AEGEAN SEA

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Abstract

The concentrations of the metals Cd, Cu, Fe, Pb and Zn, which were determined in the sediments of the coastal area of Mytilene, Lesvos island, Greece, were normalised to Al in order to compensate for the granulometric and mineralogical variations of the associated material, and metal enrichment factors were calculated. This normalisation of the metal data set revealed that Cd, Cu and Zn (and to a lesser degree Pb) were enriched in the sediments of the harbour area, but no metal enrichment was found in the sediments of the coastal area outside the harbour. Normalisation to Al is shown to be a valuable tool in assessing the degree of metal contamination in coastal sediments.

Key words : metals,sediments, pollution, Aegean Sea

Introduction

The marine environment within the vicinity of cities along the Mediterranean coastline is the final receiver of effluents (usually untreated) generated in the greater urban area. The impact of these pollutants in the coastal environment depends on the discharged pollution load and the local hydrodynamic conditions, *i.e.*, the dispersion/dilution potential of the receiving marine body [1]. Although the impact of urban effluents on marine sediments in the coastal zone of the Aegean Sea islands has been well documented [2, 3], the magnitude of this impact cannot be easily assessed because of the large granulometric and mineralogical variability of the sediments. In these areas, the metal content of the sediments is affected by land-derived detrital metals, non-detrital metals (biogenous, authigenic, hydrothermal, diagenetic) as well as metals transported in the runoff from neighbouring urban/industrial areas. In order to be able to evaluate the importance of metal contamination of marine sediments from urban sources, metal data have to be re-examined with the use (among others) of different normalisation methods [4, 5]. In the present study the metal concentrations in the coastal sediments of Mytilene were normalised to the conservative element Al and Enrichment Factors (EFs) were calculated for comparing the degree of enhancement of metal pollution in the study area.

The study area is the coastal zone near the city of Mytilene in the eastern part of of Lesvos island (Fig. 1). The only major source of anthropogenic metals in the area is the city effluents which are discharged untreated into the sea through sewage outfalls located along the urban coastline. No significant industrial activity exists in the area.

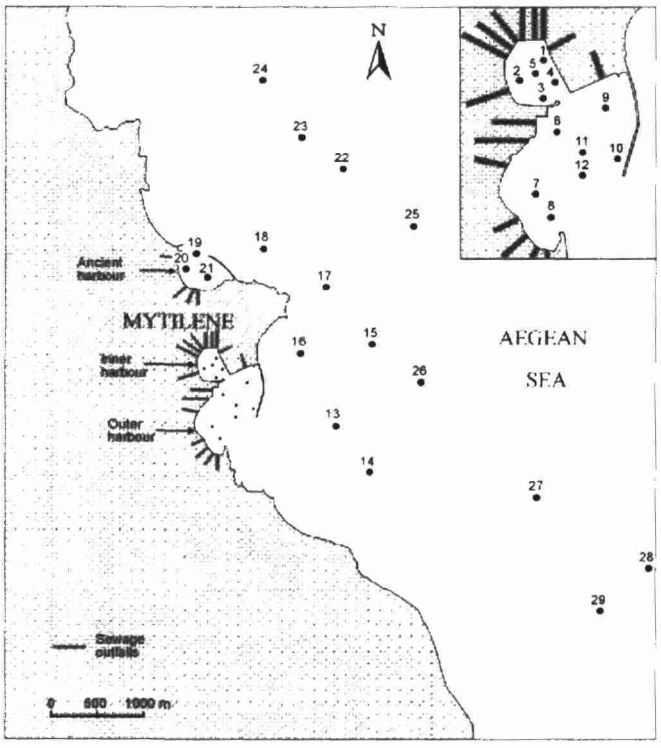

Fig. 1. Sampling stations in the coastal zone of Mytilene. Magnified insert shows the sample stations in the harbour area.

Methodology

Surface sediment samples were collected from 28 stations from the harbour and the wider coastal area of Mytilene (Fig.1). Grain size distribution was measured by wet sieving and the following fractions were determined: silt+clay (< 63 μm), sand (1 mm > x > 63 μm) and gravel (> 1 mm). The methods for the determination of organic carbon, carbonate and metal concentrations in the < 1 mm fraction are given elsewhere [6]. The quality assurance of the analytical results was controlled with the use of a Reference Material certified by NRCC (BCSS-1 marine sediment).

Normalisation to a conservative element

The term "conservative element" is used for elements of natural origin which are structurally combined to one or more of the major fine-grained trace metal carriers. Normalisation of metal levels aims to reduce the natural effect of grain size on trace metal distribution, to identify the predominant metal carriers and to estimate the extent of contamination [7]. Aluminium has been widely used as a conservative element for normalisation of metal data for marine sediments, because it is a major constituent of fine-grained aluminosilicates with which the bulk of trace metals are associated.

In non-contaminated sediments the Metal/Al ratio should be relatively constant, because it is assumed that a linear positive correlation exists between the concentration of the metal and that of Al. Since human activities normally add anthropogenic metals but not Al to the marine environment, it is assumed that contaminated sediments will present higher Metal/Al ratios. Using these ratios it is possible to calculate an "Enrichment Factor" (EF) of a metal in the sediment by dividing the Metal/Al ratio of a sample by the Metal/Al ratio of a non-contaminated sediment sample from a pristine area.

Results and discussion

The concentrations of metals in the coastal sediments of Mytilene are presented in Table 1, along with the grain size distribution (on a gravel free basis), the organic carbon content and the carbonate content of the samples. Although it is obvious that the higher metal concentrations were found in the harbour sediments, the spatial extent of metal contamination is not clear. In order to evaluate the degree of metal contamination in the area, the metal concentrations were normalised to Al. Such a normalisation is possible because in this data set a positive linear relationship exists between the concentrations of metals and the concentrations of Al and also, a positive linear relationship exists between the Al concentration and the percentage of the fine-grained material in the samples [6].

The normalised data were used to calculate the EFs for metals in the different stations by dividing the Metal/Al ratio of each station by the Metal/Al ratio of a non-contaminated reference area (Table 2). For the calculation of EFs the mean of the normalised concentrations from the 6 most remote stations of the area (stations 22, 23, 25, 27, 28 and 29) was used as a reference concentration. The mean normalised values of the non-contaminated reference area were: Cd/Al = 0.015 ± 0.005, Cu/Al = 2.64 ± 1.08, Fe/Al = 0.376 ± 0.10, Pb/Al = 8.48 ± 1.54, Zn/Al = 8.86 ± 3.37.

The calculated EFs revealed that the sediments of the harbour of Mytilene (stations 1-8 and 10-12) can be considered as polluted with Cd, Cu and Zn, because the EFs for these metals were higher than 2 (Cd pollution was recorded only at stations 1-8). Elevated Cu and Zn EFs were also found in sediments from the northern harbour of Mytilene (stations 19, 21). The value of 2 for EF as a pollution threshold has been defined arbitrarily. This value is considered appropriate