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## LANDBASED CONTRIBUTION TO THE DISTRIBUTION PATTERN OF SOME HEAVY METALS IN A SEMI-ENCLOSED EMBAYMENT

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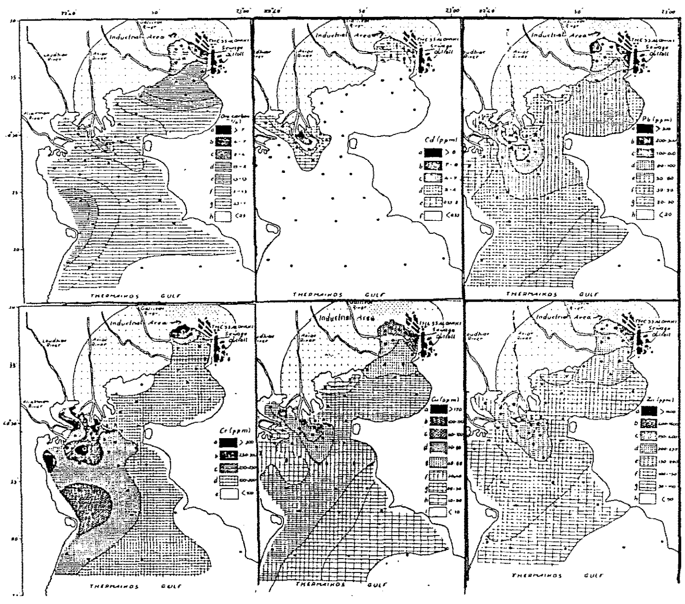
Fifty-six surface sediment samples from the Thermaikos Gulf were analysed for Cd, Pb, Cr, Cu, Zn and org. carbon in August 1985. The results showed that Pb, Cu and Zn had the same source pollution in order of importance: the sewage outfall, the industrial zone and the Axios River. The main source of Cd is the Axios River. Chromium exhibits high values in the west coast.

Introduction: In recent years, certain coastal areas and especially several land-locked embayments, such as Thermaikos Gulf, have been very rapidly affected by industrialization and the increase of population. The area under study in the north of Greece, consists of three parts, the Bay of Thessaloniki the Gulf of Thessaloniki to the south of it and the larger and further to the south, Thermaikos Gulf. About 120,000 $m^3$/day of untreated sewage water from the city of Thessaloniki, with a population of 1,200,000 inhabitants, are directly discharged into the Bay of Thessaloniki. An amount of about 25,000 $m^3$/day of treated or partially treated divers industrial effluents is released on the north western coast of the Bay, where the industrial zone is located (1). Also, on the western side of Thermaikos Gulf, the Rivers Loudhias, Aliakmon and, especially, Axios carry with them important amounts of some metals. The purpose of this work is to find out whether there have been changes since previous investigations in the area (2,3,4), adding stations near the pollution sources.

Material and Methods: In August 1985, sediment samples were collected with a 0.1 $m^2$ van Veen grab at 56 locations, which were more densely distributed in the innermost section and round the mouth of the Axios River. The samples were freeze-dried and ground to fine powder. Then, 1g of material was leached with 10 ml 50% of conc. HCl for 3 hours below boiling point. The metal level in the filtered solution was estimated on a Perkin-Elmer 305 B A.A.S. equipped with a deuterium background corrector. The technique employed was that of Satsmadjis and Voutsinou-Taliadouri (5). Organic carbon was determined by the method of Gaudette et al. (6).

Results and Discussion: Of the metals examined Pb, Cu and Zn exhibit similar distribution patterns. They present maximal concentrations near the sewage outfall (334 ppm, 172 ppm, 1610 ppm, respectively). Next to it comes the industrial zone with maximal values (245 ppm,85 ppm and 375 ppm, respectively) and the Axios River (130 ppm, 67 ppm, 252 ppm, respectively). The main source of Cd is the Axios River (8.7 ppm), then come the sewage outfall and the industrial zone (concentr. values 4.3 ppm, 3.1 ppm). A different distribution pattern is observed for Cr, the main source of it is the industrial zone (386 ppm) and the three rivers (concentr. about 280 ppm). Chromium enrichment appears to have a natural origin. Organic carbon content varies between 0.4%-7.3% with maximal value near the sewage outfall, its areal distributions is comparable with that of Pb, Cu, Zn. The unaffected section of the Thermaikos Gulf displays metal levels comparable with those of other unpolluted Greek areas (7,8,9). Maximal values of the present work compared with those from the past are much higher. This is due basically to the samples being taken closer to the sources of pollution.

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# L-III2

## SEASONAL VARIATIONS OF HEAVY METAL CONCENTRATIONS IN MUSSELS AND SEA-URCHINS SAMPLED NEAR A HARBOUR AREA

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Concentrations of heavy metals (Cd, Cu, Pb, Hg) were determined in samples of mussels (Mytilus galloprovincialis) and sea-urchins (Arbacia lixula) collected in 1984-1985 near the new harbour of Monaco. Mussels were collected at the surface and sea-urchins at a depth of 5-6 metres. Only the soft tissues of mussels and the internal parts of sea-urchins were analysed. Tissues were analysed by atomic absorption spectroscopy (graphite-furnace for Cd, Cu, Pb and cold-vapour method for Hg).

Results of determinations are shown in Tables 1 and 2 (next page). There is a general tendency for metal concentrations to increase when the average dry-weight decreases and vice-versa. This is particularly evident for mussels. One can notice for these animals a strong increase of the concentrations of the four metals for the samples collected in April 1985.

Variations of metal concentrations in mussels according to the average dry-weight of the analysed animals follow the regression equation :

$$\log(c/\bar{c}) = -0.068 - 1.786.\log.(w/\bar{w})$$

$$r = -0.667 \ (0.001 < p < 0.01)$$

$c$ = average concentration of a metal in a given sample
$\bar{c}$ = overall mean of concentrations of this metal in all samples
$w$ = average dry-weight of animals in a given sample
$\bar{w}$ = overall mean of dry-weights of animals in all samples

It can be shown that the slope of the corresponding regression line significantly differs from the theoretical slope -1.000 that one would get if the observed variations of concentration could be explained by variations of dry-weights of animals only. It appears that the mussels collected during the spring 1985 have metal concentrations which are too high to be explained by dry-weight variations only. Such high concentration values may be due to (1) a temporary augmentation of heavy metal concentrations in sea-water or (2) an increase in uptake rate due to a change in the physiological state of the animals. It is not possible to establish which hypothesis (1) or (2) is true on the basis of the data which are available. We notice, however, that the sampling of April 1985 happened in a period of phytoplankton production. Biological activity of mussels could increase, therefore, as the animals had more food at their disposal in that time.

A similar increase in heavy metal concentration was not observed for sea-urchins collected at the same time. This is probably due to the fact that mussels and sea-urchins belong to very different biological species and feed upon different foods. Heavy metal concentrations in sea-urchins seem to exhibit a general tendency to decrease when the dry-weight of the animals increases. The correlation coefficient, however, is not very high (r = -0,499, 0,02 < p < 0,05) and other analysis of these animals is necessary to check this hypothesis.

Owing to the different responses of mussels and sea-urchins to heavy metals in their environment, further research is necessary if one wants to establish precisely the possibility of using sea-urchins as pollution indicators of coastal waters.

TABLE 1 Trace metal concentrations in mussels Mytilus galloprovincialis (soft tissues)

| Sampling date | Average dry-weight (g) | Concentrations (µg.g-1 dry-weight) Cd | Cu | Hg | Pb |
|---|---|---|---|---|---|
| 1984-08-22 | 0.144 | 0.77 +/- 0.12 | 7.3 +/- 0.24 | 0.14 +/- 0.0240 | 2.1 +/- 1.20 |
| 1984-12-05 | 0.181 | 0.73 +/- 0.15 | 9.4 +/- 0.44 | 0.13 +/- 0.0220 | 1.6 +/- 0.51 |
| 1985-04-24 | 0.122 | 1.90 +/- 0.23 | 24.0 +/- 2.50 | 0.25 +/- 0.0077 | 8.9 +/- 1.70 |
| 1985-07-22 | 0.191 | 0.71 +/- 0.36 | 8.5 +/- 1.20 | 0.22 +/- 0.0280 | 2.3 +/- 0.57 |

TABLE 2 Trace metal concentrations in sea-urchins Arbacia lixula (internal parts)

| Sampling date | Average dry-weight (g) | Concentrations (µg.g-1 dry-weight) Cd | Cu | Hg | Pb |
|---|---|---|---|---|---|
| 1984-07-31 | 2.053 | 1.40 +/- 0.23 | 4.0 +/- 0.18 | 0.45 +/- 0.059 | 1.80 +/- 0.41 |
| 1984-12-05 | 1.080 | 2.00 +/- 0.46 | 8.1 +/- 1.00 | 0.53 +/- 0.036 | 4.00 +/- 0.64 |
| 1985-04-24 | 1.367 | 1.80 +/- 0.64 | 7.8 +/- 0.77 | 0.38 +/- 0.089 | 4.10 +/- 1.10 |
| 1985-07-22 | 1.608 | 0.61 +/- 0.055 | 13.0 +/- 0.77 | 0.34 +/- 0.011 | 0.95 +/- 0.29 |

Note : Means of analytical results of 5 sub-samples are given for each sample. The indicated errors correspond to probability level of 0.95.

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