

FACTORS INFLUENCING THE ACCUMULATION OF HEAVY METALS INTO THE COASTAL SEDIMENTS OF LESVOS ISLAND, GREECE

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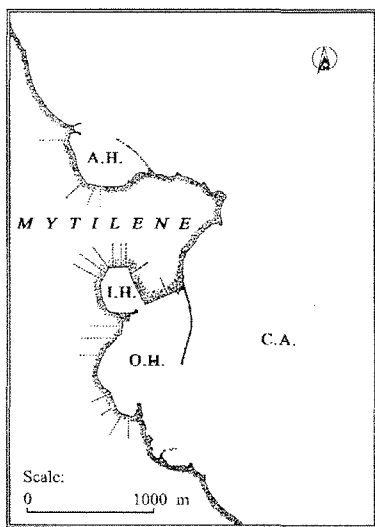


Figure 1. Study area

The urban effluents discharged into the marine coastal environment are carrying important loads of organic matter and metals (KLEIN *et al.*, 1974), in dissolved/colloidal or particulate form, which, after flocculation in the marine environment (GIBBS, 1986), settle to the bottom and are incorporated into the coastal sediments. A study conducted in the marine coastal environment of Lesbos island, near the city/harbour of Mytilene, investigated the concentrations of organic matter and heavy metals in the sediments of the area and attempted to identify the factors that influence their accumulation. The analytical techniques are presented elsewhere (ANGELIDIS *et al.*, 1994). The study area is presented in Figure 1. Along this coast, 25 sewage outfalls are discharging urban effluents containing important metal concentrations. In the Table 1 are presented the range of organic carbon and metal concentrations (0.5 N HCl extractable fraction) in four

different areas: the inner harbour (IH), the outer harbour (OH), the ancient harbour (AH) and the coastal area (CA).

In general, Cu and Zn which are the most effluent associated among the metals analyzed (KLEIN *et al.*, 1974), presented higher concentrations in the harbour sediments compared to the coastal area sediments. However, among the three harbours, the inner harbour presented the highest and the ancient harbour the lowest metal concentrations. Furthermore, the sediments from the ancient harbour had very low content of fine sediments and organic carbon, although the area also receives city effluents through a number of sewage outfalls (Figure 1). Since fine particles tend to transport the most important metal load in the sediments (GIBBS, 1977), the lack of fine sedimentary material in the ancient harbour, seems to be a key factor for the low metal concentrations found there. Because the area of the ancient harbour of Mytilene is located at the north of the city and is open to the prevailing strong northern winds of the Aegean sea, wind induced waves may resuspend and remove the finer particulate matter as well as the effluent-born flocculated colloids from the area, removing thus the greater metal load. Organic carbon load is also small in the ancient harbour sediments, probably because of the same removal process of the organic rich particulate matter, as well as because of the oxidation which is induced by

	IH	OH	AH	CA
silt-clay %	65.9-95.6	26.2-78.5	0.3-3.6	27.6-75.6
O.C %	3.3-4.8	1.9-4.3	0.1-0.9	1.4-3.4
Cr µg/g	15.8-19.3	13.7-17.1	13.2-13.4	13.2-16.0
Cu µg/g	30.7-58.9	16.7-30.4	12.6-32.7	9.4-17.5
Fe mg/g	3.7-4.2	1.8-4.0	1.8-2.3	2.3-3.8
Mn µg/g	99.7-111	103-133	87.8-92.9	95.4-133
Zn µg/g	75.0-157	27.8-105	68.8-89.3	27.9-52.4

Table 1. Concentrations of metals, O.C., and particle size in coastal sediments of Mytilene.

producing activities, urban effluents constitute an important source of metals for the marine environment. Therefore the sheltered marine areas (harbours and anchorages) near urban and tourist developments of the Mediterranean coast, may become potential metal deposits affecting thus the quality of the marine coastal environment.

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FIRST REPORT ON BIOMONITORING OF COASTAL CONTAMINATION BY TRIBUTYL TIN IN THE MEDITERRANEAN USING IMPOSEX IN A NEOGASTROPOD

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Being the active biocide in antifouling paints, very high levels of tributyltin (TBT) and its derivatives have been reported in harbour areas and yacht marinas along the Mediterranean. Chemical analysis of organotins at low environmental levels which may still be expected to cause some biological impact (ie. less than 50 ng l⁻¹), pose several analytical problems. Such problems have stimulated the use of highly specific biological responses to TBT as tools for biomonitoring purposes.

	STATION: 1	2	3	4	5	6	7	8	9
% imposex in ♀	30	60	60	94	100	100	100	100	100
RPS Index [%]	0	13	6	2	93	102	107	86	68
VDS Index [mean]	0.5	1.9	1.8	2.1	4.7	4.8	4.7	4.2	3.9
% ♀ with split capsule glands	0	10	20	0	67	72	62	16	0

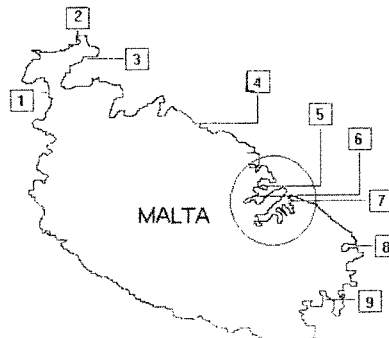


Fig. 1. Imposax in *H. trunculus* as expressed in various indices, at different sites. Harbour area are circled.

Imposax, or the development of additional male sex organs in prosobranch gastropods, has been widely used as a biomonitoring tool for TBT outside the Mediterranean. To date, no other xenobiotic except TBT, is known to cause prosobranchial imposex. The present study reports on the first biomonitoring survey of TBT levels in Mediterranean coastal waters using imposex induction in *Hexaplex trunculus* as an index. This species is one of the most common muricid in the Mediterranean. 600 specimens of *H. trunculus* were collected by divers from 9 coastal stations along the north-eastern coastline of Malta (Central Mediterranean) during the period Oct.-Dec. 1992 (Fig. 1). The degree of imposex was quantified by various indices, including: the Relative Penis Size Index (RPS) which is the ratio between the cubed mean penis length in imposed females to that in males for a given population; and the Vas Deferens Sequence (VDS) Index, whereby imposex development is divided into various stages of vas deferens development, with each stage being given a score. A synthesis of the data is presented in Fig. 1. All populations showed some degree of imposex, which was however mostly evident in harbour areas exposed to release of TBT from yacht marinas and ship-repairing yards. Stations which were located downstream with respect of the harbour areas (the prevalent surface coastal water currents being from the NW), also exhibited significant degrees of imposex induction in this species. This phenomenon was moreover related to the levels of TBT in the organisms as well as in sediments. Details of analytical methods and levels of butyltins in biota and sediments are presented elsewhere (AXIAK *et al.*, in press). Fig. 2 shows the relationship between the levels of TBT in digestive glands/gonads of females and RPS indices, with the estimated logarithmic correlation line also being shown. The various imposex indices were found to increase sharply at very low levels of butyltins and then to level off also at relatively low levels of the contaminants. Based on a logarithmic correlation line, a 50% index value for RPS was reached at 6 ng Sn g⁻¹ dry weight (DW) in the digestive gland/gonad, and at estimated levels of as low as 3.5 ng Sn g⁻¹ DW for TBT in whole soft flesh of females. In fact there is evidence to suggest that of all the neogastropod species investigated so far, this species is the most sensitive with respect to its biological response to TBT. This is evident from a comparative review of the relative sensitivities in imposex response to TBT levels in a series of neogastropods as shown by AXIAK *et al.* (in press).

Most of the body burdens of TBT (but not of DBT and MBT) were generally found in the digestive gland of exposed snails, indicating that feeding is the major route of uptake of this contaminant for this test species. Females tend to accumulate more TBT than males. No preferential female mortalities was recorded in populations exposed to high levels of TBT. However, a reported shift in the size frequency distribution of animals in contaminated sites, towards bigger snails, may suggest reduced reproductive potential. Imposax in females may lead to sterility either through the occlusion of the vagina or the splitting of the capsule gland. While vagina occlusion does not occur in this species, the majority of females in the highly contaminated sites exhibited split capsule glands. Further data is required to assess whether imposex in this species is leading to sterility of females.

This study has shown that imposex induction in this test species is a highly specific biomarker response; it may be easily quantified; it is extremely sensitive to very low levels of butyltins; it is fast and cost-effective and as such satisfies all criteria for a useful biomonitoring tool which may be applicable to the whole Mediterranean.

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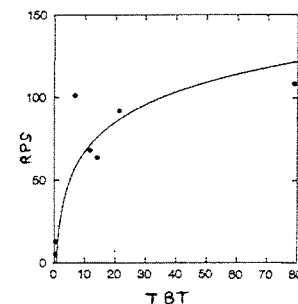


Fig. 2. Relation between TBT in digestive gland/gonad of females (ng Sn/g dry weight) and RPS index (%)