

Distribution of mercury and methyl mercury in tissues of transplanted mussels

ZORANA KLJAKOVIĆ-GAŠPIĆ¹, NIKŠA ODŽAK¹, TOMISLAV ZVONARIĆ¹,
MILENA HORVAT² & ANTE BARIĆ¹

¹Institute of Oceanography and Fisheries, Split, Croatia; E-mail: kljakovic@izor.hr

²Institute Jožef Stefan, Ljubljana, Slovenia; E-mail: milena.horvat@ijs.si

Abstract: Total mercury and methyl mercury concentrations were determined in whole soft tissue, gills and digestive gland of mussels from the Kaštela Bay, which is polluted with inorganic mercury. Concentrations of total mercury in the digestive gland were 1.5-5.5 times higher than in the whole soft tissue and gills, while concentrations of MeHg were similar in all analyzed tissues. The percentage of methyl mercury in the digestive gland (4-11 %) was lower in comparison to the gills (12-25 %) and the whole soft tissue (13-27 %). A negative correlation was observed between the total mercury concentration in the tissues and the percentage of methyl mercury.

Key words: mercury, mussels, transplanted, biomonitoring, Kaštela Bay

INTRODUCTION

The Kaštela Bay is the largest bay in the central part of the Croatian coast (Fig. 1). In the period from 1949 to 1990, the Bay has been exposed to pollution by inorganic mercury derived from a chlor-alkali plant (Fig. 1). The total amount of elemental mercury discharged into the bay is estimated at 39 tons^[1]. Even though the chlor-alkali plant was closed 14 years ago, elevated levels of total mercury are still evident in surface sediments^[2, 3], and surface waters of the bay^[3, 4]. Previous studies showed that mercury concentrated in sediment close to the plant is being dispersed throughout the bay by remobilization processes^[2, 5, 6].

In order to assess the availability of remobilized mercury and methyl-mercury to marine organisms, we performed an active biomoni-

toring experiment in the bay in the period from September 2000 to March 2001. Mussels (*M. galloprovincialis*) were transplanted from the shellfish-breeding farm in the Mali Ston Bay to 4 stations in the Kaštela Bay (Fig. 1). Samples were collected every second month. More detailed description of the experiment is given elsewhere^[6].

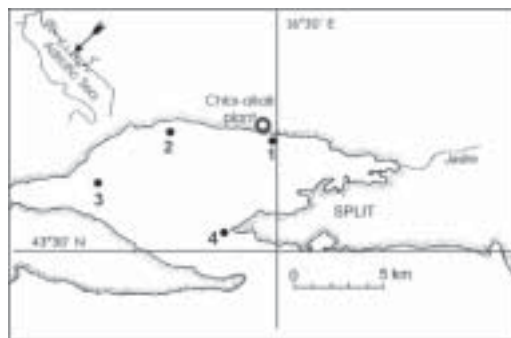


Figure 1. Kaštela Bay with experimental stations.

RESULTS AND DISCUSSION

Total Mercury: Temporal variations of total mercury in analyzed tissues are presented in Fig. 2. Concentrations of total mercury in the digestive gland (320-1349 ng g⁻¹ d.wt.) were 1.5-5.5 times higher than in the whole soft tissue (138-325 ng g⁻¹ d.wt.) and gills (121-380 ng g⁻¹ d.wt.) (Fig. 2). These values are similar to the values usually found in the areas with the history of the contamination with mercury from different industrial sources. The process of mercury accumulation in the mussels transplanted from the referent station was very rapid at all stations. The highest differences were recorded at station 1. After 2 months, concentration of Hg in digestive gland at this station was 7 times higher in comparison to the initial period. In following months the decrease of Hg concentration in digestive gland was followed with the increase in the whole soft tissue. This is probably related to internal transport and redistribution.

Spatial distribution of bioavailable species of total mercury was in the accordance with the prevailing circulation of water mass in the bay^[1]. The average concentrations of total Hg in mussel tissues decreased in an anti-clockwise direction towards the exit of the bay (1>2, 3>4). Described spatial distribution of Hg in mussel tissues is similar to the spatial distribution of total Hg in the surface sediments^[2], which indicates successful transport of Hg from sediments to the filter-feeding organisms. This could be expected since investigations in coastal areas showed that total mercury concentrations in mussels are strongly correlated with the mercury content of sediments and particulate matter^[7].

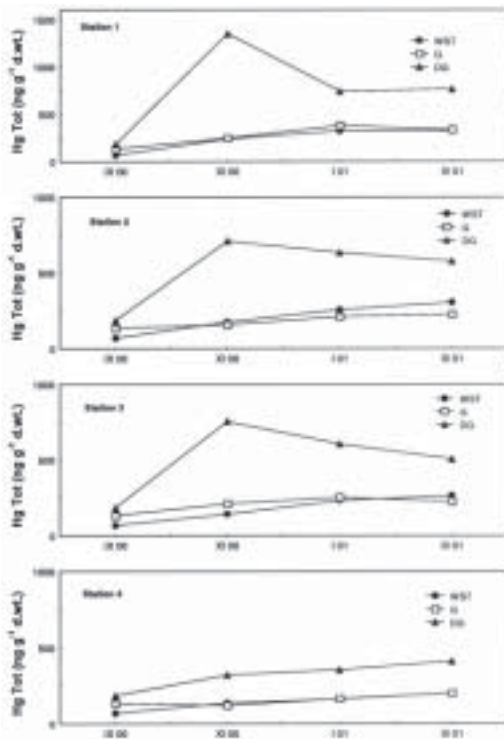


Figure 2. Variations of total Hg (ng g⁻¹ d.wt.) in the whole soft tissue (WST), gills (G), and digestive gland (DG) of mussels.

Methyl-mercury: Concentrations of MeHg were similar in all analyzed tissues, and covered a narrow range of 22.7-59.3 ng g⁻¹ d.wt. (Fig. 3). These values are significantly lower in comparison to the period before the chlor-alkali plant was closed^[8]. However, they are still higher in comparison to the uncontaminated areas. Enrichment factors of MeHg in tissues two months after transplantation were 1.6-2.5, 2.1-2.5, and 2-2.7, respectively, for digestive gland, whole soft tissue and gills. Increase of MeHg concentration in the whole soft tissue, and the decrease in digestive gland in period from November to January is probably related to internal transport.

Spatial distribution of MeHg was similar to the distribution of the total Hg. Thus, concentrations of MeHg decreased from Station 1 in an anticlockwise direction towards the exit of the bay.

Ratio MeHg/total Hg: The percentage of methyl mercury in the digestive gland (4-11 %) was lower in comparison to the gills (4-11 %) and the whole soft tissue (12-25 %) (Table 1). The percentage of mercury in the methylated form in mussel tissues in the marine environment can range from 14% to almost 100 %^[8, 9], depending on the stage of contamination with mercury. However, the higher values are usually recorded in mussels from the uncontaminated areas. Our results support this statement. We observed that a negative correlation exists between the total mercury concentration in the tissues and the percentage of methyl mercury. Thus, the highest percentage of MeHg was recorded at station 4, where the concentrations of inorganic mercury are the lowest. This negative correlation is probably the result of the low production rate of MeHg in the ecosystem, which cannot compete with the large flux of inorganic mercury from the sediment^[8].

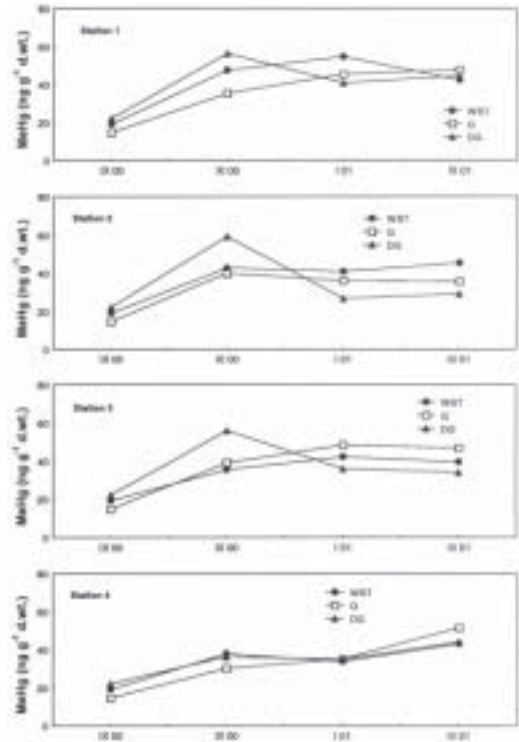


Figure 3. Variations of total MeHg (ng g⁻¹ d.wt.) in the whole soft tissue (WST), gills (G), and digestive gland (DG) of mussels.

Table 1. Percentage of total mercury in the methylated form (%) in the whole soft tissue, gills and digestive gland of mussels from the Kaštela bay.

		WHOLE SOFT TISSUE				GILLS				DIGESTIVE GLAND			
DATE	STATION	1	2	3	4	1	2	3	4	1	2	3	4
	IX 2000		27	27	27	27	11	11	11	11	12	12	12
XI 2000		20	24	25	27	14	25	18	25	4	8	7	11
I 2001		17	16	18	21	12	17	19	21	6	4	6	10
III 2001		13	15	15	21	14	16	21	25	6	5	7	11

CONCLUSIONS

- Mercury is still one of the main pollutants in the Kaštela Bay.
- The concentration pattern of total and methyl mercury in mussel tissues is similar to the spatial distribution of total Hg in the surface sediment.
- Spatial distribution of bioavailable species of mercury is in the accordance with the prevailing circulation of water mass in the bay.
- The percentage of methyl-mercury in mussel tissues (4-25 %) is characteristic for the areas contaminated with inorganic mercury.
- The digestive gland is very sensitive monitoring tool for the assessment of the bioavailability of remobilized mercury in the marine environment.

REFERENCES

- [1] CIMIS (1993): Projekt "Gospodarenje Prostorom Kaštelanskog Zaljeva": Sinteza Prvog Ciklusa Rada 1988-1993, pp. 177, Sveučilište u Splitu, Split.
- [2] ODŽAK, N., ZVONARIĆ, T., HORVAT, M. (1996): Mercury Distribution in the Surface Sediments of the Kaštela Bay, pp. 493: *Fourth International Conference on Mercury as a Global Pollutant*, Hamburg.
- [3] KWOKAL, Z., FRANČIŠKOVIĆ-BILINSKI, S., BILINSKI, H., BRANICA, M. (2002): A Comparison of Anthropogenic Mercury Pollution in Kaštela Bay (Croatia) with Pristine Estuaries in Ore (Sweden) and Krka (Croatia); *Marine Pollution Bulletin* 44/10, pp. 1152-1157.
- [4] HORVAT, M., KOTNIK, J., LOGAR, M., FAJON, V., ZVONARIC, T., PIRRONE, N. (2003): Speciation of Mercury in Surface and Deep-Sea Waters in the Mediterranean Sea; *Atmospheric Environment* 37/Supplement 1, pp. 93-108.
- [5] MIKAC, N., PICER, M. (1985): Mercury Distribution in a Polluted Marine Area. Concentrations of Methyl Mercury in Sediments and Some Marine Organisms; *The Science of The Total Environment* 43/1-2, pp. 27-39.
- [6] ODŽAK, N., ZVONARIĆ, T., KLJAKOVIĆ-GAŠPIĆ, Z., HORVAT, M., BARIĆ, A. (2000): Biomonitoring of Mercury in the Kaštela Bay Using Transplanted Mussels; *Science of the Total Environment* 261/1-3, pp. 61-68.
- [7] LANGSTON, W. J. (1986): Metals in Sediments and Benthic Organisms in the Mersey Estuary; *Estuarine Coastal and Shelf Science*, pp. 23239-261.
- [8] MIKAC, N., PICER, M., STEGNAR, P., TUŠEK-ZNIDARIĆ, M. (1985): Mercury Distribution in a Polluted Marine Area. Ratio of Total Mercury, Methyl Mercury and Selenium in Sediments, Mussels and Fish; *Water Research* 19/11, pp. 1387-1392.
- [9] RIISGARD, H. U., KIORBOE, T., MOHLENBERG, F., DRABAEK, I., MADSEN, P. P. (1985): Accumulation, Elimination and Chemical Speciation of Mercury in the Bivalves *Mytilus Edulis* and *Macoma Balthica*; *Marine Biology* 86/1, pp. 55-62.