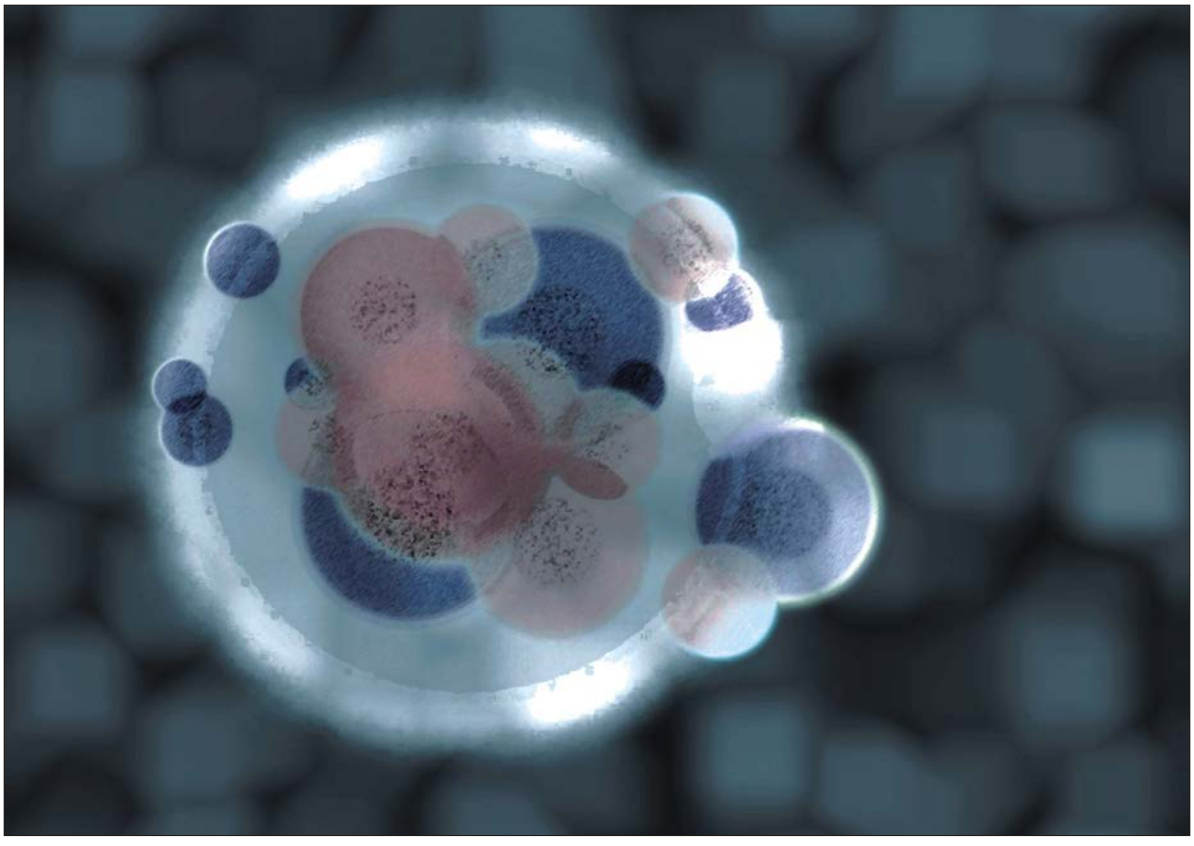

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Mercury (Hg) Levels in the Mediterranean Mussel (*Mytilus galloprovincialis*) on Bosphorus, Istanbul, Turkey

Figen Esin Kayhan
Department of Biology, Faculty of Science and Art, Marmara University,
81040, Göztepe, İstanbul, Turkey

Abstract: In this study, mercury (Hg) levels in Mediterranean mussel (*Mytilus galloprovincialis* Lamarck, 1819) has been evaluated. The mussels are collected from six different regions of the coast of Bosphorus on seasonal basis from 2002 to 2004. The mussels are divided into two groups concerning their shell length. Hg levels were determined in the seasonal periods from each station and the heavy metal results obtained from the samples were expressed as the annual result of two different regions: The European side and Asian side of Bosphorus. The results reveals out that, there is severe pollution and deposition of mercury in the mussels living at the Bosphorus, at the same time it has been found that the pollution is worse at the European side comparing with the Asian shore.

Key words: Bosphorus, marine pollution, mercury, *Mytilus galloprovincialis*

INTRODUCTION

Bosphorus is a unique water passage between Black Sea and Marmara Sea. For many years investigators focused on a regional aquatic ecosystem, the Bosphorus, monitoring heavy metal in sediments (Balkıs and Algan, 2005) and mussels (Akdoğan and Ünsal, 1993; Topçuoğlu *et al*., 2004; Göksu *et al*., 2005) considered as biomonitors of heavy metal pollution. The mussels *Mytilus* spp., as sedentary filter-feeders, are known to be good bioaccumulators of some trace elements and tissue concentrations appear to reflect contamination of heavy metals (Soto, 1997; Szefer, 1999). All heavy metals are potentially harmful to most organisms at some level of exposure and absorption. Aquatic animals are also exposed to elevated levels of heavy metals. Some trace metals are essential in low concentrations for the metabolism of animals, but in the excess all trace metals are toxic (Rainbow, 1997). The levels of trace metals in soft tissues of mussels have been discussed in various investigations (Storelli *et al*., 2000; Besada *et al*., 2002; Sunlu, 2002; Topçuoğlu *et al*., 2004; Türkmen *et al*., 2005). Some trace metals such as Hg, Cd, Pb, Zn can accumulate in molluscs and shellfish, mainly hepatopancreas, in gonads and in gills. Some trace metal levels in soft tissue in mussels have been discussed in all of the investigations concerned. Therefore mussels especially have been used as biological indicator organisms to monitor marine pollution by toxic heavy metals and potentially toxic chemicals due to their own properties of inhabitation (Gundacker, 1999; Pempkowiak, 1999; Hu, 2000). A study from Italy, the concentrations of zinc, manganese, copper, cadmium, lead and mercury have been determined in soft tissues of four marine organisms (*Mytilus galloprovincialis*, *Nephrops norvegicus*, *Mullus barbatus*, *Engraulis encrasicolus*) collected seasonally from different areas of the Tyrrhenian Sea. In all four species levels of these metals, except mercury in all areas are alike while mercury levels vary and, furthermore, are higher than in specimens from other areas of the Mediterranean and also from other seas. This result has shown that, mussels can accumulate high concentrations of mercury in their soft tissues (Leonzio *et al*., 1981). Usually, metal concentrations are evaluated in soft tissue of mussels. Some trace metals are essential in low concentrations for the metabolism of animals, but in the excess all trace metals are toxic (Avelar *et al*., 2000; Rainbow, 1997). In some places, the consumptions of mussels has been impeded by elevated levels of metallic toxicants such as mercury. Large amounts of mercury were released into Minamata Bay from a chemical plant until around 1970. This environmental pollution seriously affected human health as an illness named Minamata disease officially registered in 1956 (Harada, 1995). In recent years, heavy metal accumulation in fish and other aquatic organisms has been investigated along the coasts of Turkey. Sea of Marmara, Aegean Sea, Black Sea and Mediterranean Sea have been exposed to more heavy metal pollution depending on industrial pollution from the different facilities, took place around it (Öztürk, 1991; Ünsal and Beşiktepe, 1994. Egemen *et al*., 1997; Topçuoğlu *et al*., 2004; Göksu *et al*., 2005; Türkmen *et al*.,

2005). Estimates of intake of heavy metals were made through seafood consumption by the general population. Turkish legal standard is 0.5 ppm for Hg in bivalve molluscs (Anonymous, 2002). The aim of this study is to measure concentration of mercury in the mussels of Bosphorus. For this purpose *Mytilus galloprovincialis* is chosen as a biomonitor of coastal heavy metal pollution.

MATERIALS AND METHODS

The mussels are divided into two groups concerning their shell length. The small group's shell length were between 1.5-3.5 cm and the big group's shell length were between 4.0-7.5 cm. The samples of *Mytilus galloprovincialis* was hand-collected, from the six stations shown in the map (Fig. 1). Two hundred forty Mussel samples were collected from the area during January 2003 to December 2004. These samples are classified as small and big sizes for comparing purposes and also divided into two geographic groups (Asian side and European side) to see if there is any difference in pollution on both sides of Bosphorus.

The recommendations regarding sampling, handling and specimen storage were followed as described in the FAO Fisheries Technical Paper (FAO, 1976). After collection, the samples were transported to the laboratory and the mussels were rinsed with clean water. Samples were placed in polyethylene bags and stored below -20°C pending analysis. The soft parts were carefully removed with a plastic knife and homogenized in a mixer to make up the sample from each sampling station. To avoid metal contamination, the mixer was covered with teflon for all the parts that came into contact with the sample. About 0.5 g of sample (dry weight) were digested in quartz erlenmayer flasks and 2 mL of concentrated nitric acid (HNO_3) was added to each flask and the solution was evaporated to dryness on a hot plate at 40°C. After this procedure, the digested samples were diluted to 10 mL with deionized distilled water. All chemicals used in sample treatments were of ultrapure grade (HNO_3, Merck Suprapur) and ultrapure water (Millipore, Milli Q) (Bernhard, 1976; Loring and Rantala, 1992).

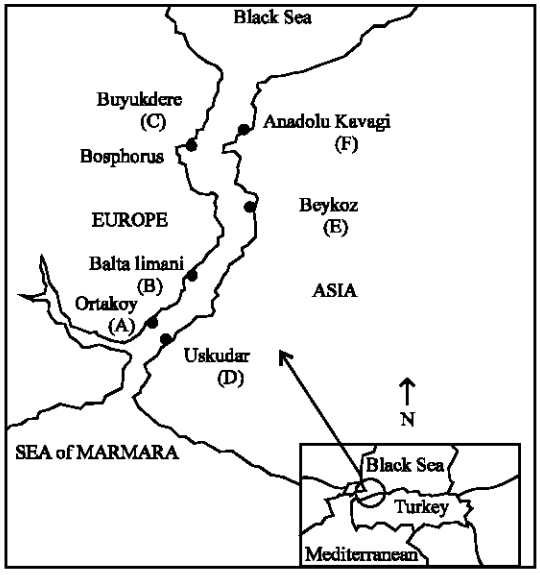

Fig. 1: Sampling areas in the Bosphorus, Istanbul, Turkey

Concentrations of Hg in soft tissues of *Mytilus galloprovincialis* were determined by atomic absorption spectrometry (Schimadzu 6701 F). Mercury concentration was measured by cold vapour technique. One-way analysis of variance (ANOVA) and Duncan's test ($p = 0.05$) were used in order to access whether mercury concentrations varied significantly between stations and different sides of Bosphorus. The probabilities less than 0.05 ($p<0.05$) were considered statistically significant. All statistical calculations were performed with SPSS 9.0 for Windows.

RESULTS

This study was designed to investigate the current Hg contamination of *Mytilus galloprovincialis*. At the European side of Bosphorus, the dry weight Hg concentrations in big size mussels varied from 1.04 to 2.86 and 1.18 to 2.16 ppm in the small sizes. At the Asian coast of Bosphorus, Hg concentrations in the big size mussels varied from 1.03 to 2.94 and 1.11 to 1.58 ppm in the small sizes.

The levels of mercury measured in *Mytilus galloprovincialis* from the six stations are presented in Table 1, respectively.

The concentrations of Hg in mussels were consistently higher according to Turkish legal standards. Turkish legal standard is 0.5 ppm for Hg in bivalve molluscs (Anonymous, 2002). The concentrations of

Table 1: Concentrations of Hg levels (ppm) in the soft tissue of mussels at the six stations from Bosphorus

Mercury levels		European side			Asian side		
		A	B	C	D	E	F
Hg (big size)	Spring	1.87	2.39	1.96	2.12	1.99	1.03
	Summer	1.04	1.89	2.18	1.66	1.82	1.19
	Fall	2.86	2.38	2.58	2.94	1.98	1.62
	Winter	0.14	2.00	1.71	2.80	1.56	1.56
Hg (small size)	Spring	1.28	1.69	1.91	1.39	1.55	1.58
	Summer	1.18	1.81	1.92	1.27	1.36	1.26
	Fall	1.36	1.51	2.16	1.39	1.11	1.48
	Winter	1.55	2.12	2.00	1.30	1.53	1.52

(means±SD ppm dry weight). (n = 240) (Sampling points: A: Ortaköy, B: Balta Limani, C: Büyükdere, D: Üsküdar, E: Beykoz, F: Anadolu Kavağı)

mercury in mussels taken from European coasts were statistically higher than the levels of those metals taken from the samples of Asian side ($p<0.05$).

DISCUSSION

The Bosphorus which is within the administrative port limits of İstanbul, lies between the parallels of latitude of 41° 01'N and 41° 13'N and its length is 17 nautical miles. The shores on both sides are densely populated and closely-packed buildings are interspersed with parks, gardens and restaurants (Akten, 2002). Surface flow of Bosphorus comes from the Black Sea, in north-south direction, whereas more salty deep flow goes from Marmara Sea to Black Sea from south to north. Black Sea has no drainage other than Bosphorus and it is severely polluted by the big rivers like Douna, Don and Dinieper. On the other hand the city of Istanbul, located on the shores of Bosphorus, with a population exceeding 13 million, herself is also polluting the sea with industrial effluents and domestic sewage. Bosphorus is also a very important waterway for oil transportation. Every year millions of tons of oil have been transported by tanker ships and due to unfortunate accidents and leakages do occur (Güven *et al*., 1995). This study has shown that the mussels collected from Bosphorus have increased amounts of mercury. We also founded that mercury level of mussels coming from European side is higher than those coming from Asian side. This result is not surprising, since, both the population and the number of industrial settlements are located especially at the European side. It is well known that pollutants are potentially accumulated in marine organisms and sediments and subsequently transferred to man through the food chain (Giordano *et al*., 1991). Moreover, the affiance of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism and the contamination gradients of water, food and sediment, as well as other factors such as salinity, temperature and interacting agents (Romeo *et al*., 1999). Among other molluscs living in Bosphorus we have chosen *M. galloprovincialis*, since they play an important role as bioindicator for trace metal pollution and appear more and more often in global monitoring programs (Goldberg *et al*., 1978; Rainbow, 1995; Soto, 1997; Sericano, 2000). Also Gundacker (1999) states out that blue mussels and Mediterranean mussels accumulate high amounts of toxic heavy metals and are widely used as a bio-monitoring organisms. We have found the concentrations of mercury in mussels consistently higher according to Turkish legal standards. In addition, the concentrations of mercury in mussels taken from European coasts were statistically higher than the levels of those metals taken from the samples of Asian side. Şentürk (1993) found Hg, Cdand Pb levels on the mussels from different regions of the Marmara Sea. In the analysis of the samples for residues of heavy metals, the average values were found to be: 0.25 ppm for Cd and 0.304 ppm for Pb. Evaluation of their study's results showed that Cd and Pb levels were within the normal ranges for our country and other country's acceptable limits. These studies were done more than one decade ago. Our results have shown a more severe pollution when compared with them. Although the civil authorities and city municipality spends remarkable effort to stop the pollution, our study shows that this problem and its harmful effects still continues.

Akdoğan and Ünsal (1993) examined the relationship between Zn, Cu and Hg content, shell length and body dry weight for two different size groups of *Mytilus galloprovincialis* collected from Rumeli Hisari port in Bosphorus in different seasons. Maximum Hg concentrations was observed in fall in soft tissues of big sized mussels, in small sized individuals however the highest Hg concentration was measured in summer. These are similar results for our study. Storelli *et al*. (2000) has investigated Hg and some heavy metal concentrations in *Mytilus galloprovincialis* at Ionian Sea, Italy. At the end of the analysis, it was observed the Hg concentration was found: 0,15 ppm. This result was normal range for human consumption. We have observed higher Hg levels than Storelli *et al*. (2000).

We have founded the highest levels of mercury in the Bosphorus' molluscs when compared with other studies. As we mentioned above, one of the main reasons of pollution in Bosphorus is thought to be the severe pollution at the Black Sea, since the water is flowing from north to South, from Black Sea to Marmara Sea, via Bosphorus. But the existing literature doesn't support this suggestion. An explanation might be that Istanbul's industrial effluents and domestic sewage is a major pollutant than we think. We need more researches to make statements about that. The concentrations of mercury in the Mediterranean mussels (*Mytilus galloprovincialis*) from six different locations of the Bosphorus were measured by atomic absorption spectrophotometry for monitoring heavy metal pollution in the coastal water. Our results showed higher levels of mercury when compared with the previous studies. The major findings of this study are that mercury concentrations in the soft tissue of *Mytilus galloprovincialis* from the Bosphorus were very high and in general displayed significant variation from station to station. Certain mercury level reached unacceptable levels for human consumption. Because

high metal concentrations in tissue can have toxic effects on mussel metabolism, it is important to consider the biological effects of contamination on mussel health in the aquatic systems. From the public health point of view, the level of the metal found in this study were generally higher than the permitted levels and those of previous studies.

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