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Cadmium (Cd) and Lead (Pb) Levels of Mediterranean Mussel (*Mytilus galloprovincialis* Lamarck, 1819) From Bosphorus, İstanbul, Turkey

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Abstract: In this study, bioaccumulation of cadmium (Cd) and lead (Pb) in Mediterranean mussels (*Mytilus galloprovincialis* Lamarck, 1819) at Bosphorus, İstanbul, Turkey, has been researched. Mussel samples hand-collected seasonally, between January, 2003 and December, 2004 from six stations in Bosphorus. The concentrations of Cd and Pb in the mussels were determinated by Atomic Absorption Spectrometry (AAS). The results of this study indicated that Cd and Pb were in higher concentrations in the Mussels of Bosphorus. The concentrations of these metals in soft tissues exceeded the acceptable levels for a food source for human consumption and these values are unacceptable for Turkish legal standards.

Key words: Bosphorus, cadmium, lead, marine pollution, *Mytilus galloprovincialis*

INTRODUCTION

All heavy metals are potentially harmfull 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 (Rainbow, 1995; Mengi *et al*., 1998; Bat *et al*., 1999; Storelli *et al*., 2000; Besada *et al*., 2002; Sunlu, 2002; Topçuoğlu *et al*., 2004; Türkmen *et al*., 2005). Trace metals such as Cd, Pb, Hg, Zn accumulate mainly at the hepatopancreas, gonads and in the gills of molluscs and shellfishes. 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 (Pempkowiak *et al*., 1999; Hu, 2000).

Although some heavy metals such as cadmium and lead have less biological importance they are also natural trace components of the aquatic environment and changes in their levels are good indicators of increased industrial, agricultural and mining activities. Mussels can accumulate Cd in their tissues at levels to 100,000 times higher than the levels observed in the water in which they live (Avelar *et al*., 2000). Isani *et al*. (1997) have detected Cd in the soft tissue of molluscs and Cardellicchio *et al*. (1998) reported that mussels accumulate metals with a bioconcentration factor ranging between 10^3 and 10^6 with respect to seawater (Isani *et al*., 1997; Cardellicchio *et al*., 1998; Juresa and Blanusa, 2003). 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; Bat *et al*., 1999; Topçuoğlu *et al*., 2004; Yazkan *et al*., 2004; Göksu, 2005; Türkmen *et al*., 2005). Estimates of intake of these elements were made through seafood consumption by the general population. Turkish legal standards, are 1.0 ppm for Cd and 2.0 ppm for Pb in bivalve molluscs (Anonymous, 2002). The aim of this study is to measure concentrations of lead and cadmium in the mussels of Bosphorus, Istanbul. For this purpose Mediterranean mussel (*Mytilus galloprovincialis*) is chosen as a biomonitor of coastal heavy metal pollution.

MATERIALS AND METHODS

The samples of *Mytilus galloprovincialis* was hand-collected, from the six stations shown in the map (Fig. 1). 480 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

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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.

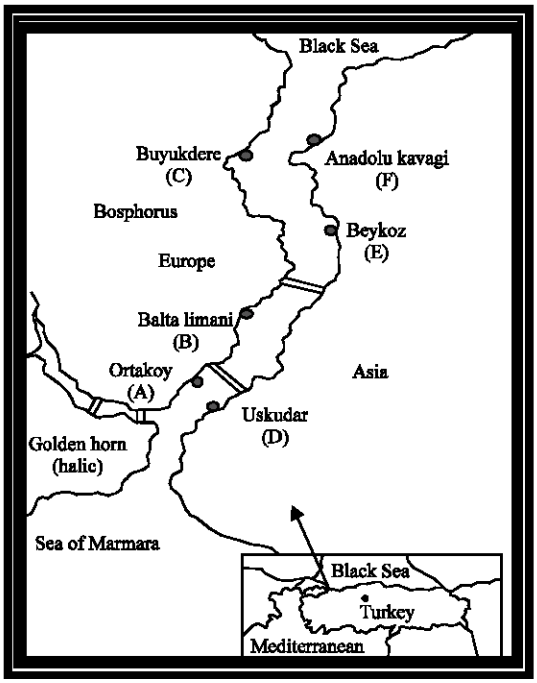

Fig. 1: Sampling areas in the Bosphorus, İstanbul, Turkey

About 1 g of samples (dry wt.) were digested in quartz erlenmayer flasks and 10 mL of concentrated HNO_3:$HClO_4$ (5:1) was added to each flask and the solution was evoporated to dryness on a hot plate at 120°C. After allowing the flasks to cool, 10 mL of N/10 HCl was added to bring the volume to 50 mL. All chemicals used in sample treatments were of ultrapure grade (HNO_3, H_2O_2 30%, Merck Suprapur) and ultrapure water (Millipore, Milli Q) (Bernhard, 1976; Loring and Rantala, 1992).

Concentrations of Cd and Pb in soft tissues of Mediterranean mussel (*Mytilus galloprovincialis*) were determined by atomic absorption spectrometry (Schimadzu 6701 F). One-way analysis of variance (ANOVA) and Duncan's test ($p = 0.05$) were used in order to access whether cadmium and lead 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 cadmium and lead contamination of *Mytilus galloprovincialis*. At the European side of Bosphorus, the dry weight cadmium concentrations in big size mussels varied from 0.30±0.12 to 6.90±0.90 ppm and 0.33±0.09 to 8.98±1.70 ppm in the small sizes. Lead concentrations in big size mussels varied from 1.06±0.20 to 6.10±0.90 ppm and 0.06±0.09 to 9.38±2.17 ppm in the small sizes. At the Asian coast of Bosphorus, cadmium concentrations in the big size mussels varied

Table 1: Concentrations of Cd and Pb levels (ppm) in the soft tissue of mussels at the six stations from Bosphorus, İstanbul, Turkey (means±SD ppm dry weight). (n=480)

Concentration levels		Eurorean side of Bosphorus (Sampling stations)			Asian side of Bosphorus (Sampling stations)		
		A	B	C	D	E	F
Cd (big size)	Spring	2.29±0.69	0.30±0.12	2.83±0.57	0.65±0.31	0.55±0.08	0.72±0.13
	Summer	3.09±0.52	0.91±0.21	1.32±0.29	7.65±1.30	1.94±0.29	0.71±0.13
	Fall	2.00±0.39	2.84±0.65	3.27±0.63	1.23±0.23	0.31±0.30	0.64±0.08
	Winter	6.90±0.90	2.14±0.50	1.02±0.21	3.05±0.55	0.57±0.08	0.45±0.19
Cd (small size)	Spring	8.98±1.70	0.99±0.30	0.54±0.19	0.67±0.21	3.22±0.56	0.87±0.29
	Summer	1.89±0.50	1.86±0.49	0.33±0.09	0.57±0.26	0.30±0.09	0.59±0.11
	Fall	1.56±0.29	1.97±0.45	2.38±0.50	3.99±0.55	0.71±0.13	0.63±0.18
	Winter	5.78±1.47	1.60±0.26	0.68±0.13	2.08±0.41	0.53±0.12	0.63±0.18
Pb (big size)	Spring	3.58±0.56	1.20±0.22	5.58±0.90	2.73±0.65	1.37±0.29	0.78±0.17
	Summer	4.46±0.84	2.19±0.41	6.10±0.90	3.11±0.63	1.00±0.26	2.56±0.57
	Fall	4.23±0.78	1.06±0.20	2.59±0.39	2.70±0.40	1.11±0.27	2.83±0.63
	Winter	2.03±0.60	7.92±1.40	1.12±0.26	6.23±0.91	6.14±1.41	0.71±0.17
Pb (small size)	Spring	1.14±0.29	1.35±0.28	2.83±0.57	3.42±0.79	1.78±0.25	3.12±0.64
	Summer	0.06±0.09	6.02±1.45	3.65±0.51	3.27±0.65	0.82±0.18	2.00±0.39
	Fall	3.09±0.41	4.83±0.80	9.38±2.17	1.75±0.19	3.39±0.73	2.94±0.61
	Winter	2.90±0.69	2.59±0.61	0.63±0.31	6.47±0.90	7.56±1.20	4.56±1.16

(Sampling stations: A: Ortakoy, B: Balta Limani, C: Buyukdere, D: Üskudar, E: Beykoz, F: Anadolu Kavagi)

from 0.31±0.30 to 7.65±1.30 ppm and 0.30±0.09 to 3.99±0.55 ppm in the small sizes. Lead concentrations in the big size mussels varied from 0.71±0.17 to 6.23±0.91 ppm and in the small size mussels values varied from 0.82±0.18 to 7.56±1.20 ppm.

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

The concentrations of cadmium and lead in mussels were consistently higher according to Turkish legal standards. The concentrations of cadmium and lead 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

Bosphorus is a unique water passage between Black Sea and Marmara Sea. For many years investigators focused on a regional aquatic ecosystem, the Bosphorus, İstanbul, monitoring heavy metal in sediments (Balkis and Algan, 2005) and mussels (Akdoğan and Ünsal, 1993; Mengi *et al*., 1998) considered as biomonitors of heavy metal pollution. Length of Bosphorus is almost 31 km and the width of this natural cannal varies from 0.7 to 3.5 km 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 drenage other than Bosphorus and it is severely polluted by the big of Europa 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 cadmium and lead. We also founded that cadmium and lead levels of mussels coming from European side is higher than those coming from Asian side. This result is not surprising, since, both the urban population and the number of industrial settlements are located especially at the European side. Pastor *et al.* (1994) observed that heavy metal accumulation in molluscs depends on some environmental factors, as temperature, salinity, contamination of water and biological factors, such as age, diet, reproductive state and sex. It is well known that pollutants are potentially accumulated in marine organisms and sediments and subsequently trasferred 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 *Mytilus galloprovincialis*, since they play an important role as bioindicator for trace metal pollution and appear more and more often in global monitoring programs (Goldberg, 1978; Rainbow,1995; 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. Bivalve molluscs especially mussels, fulfil all the requirements mentioned above, therefore, it is appropriate to act as a biological indicator of pollution. (Goldberg *et al*., 1986; Soto *et al*., 1997). We have found the concentrations of cadmium and lead in mussels consistently higher according to Turkish legal standards. In addition, the concentrations of cadmium and lead in mussels taken from European coasts were statistically higher than the levels of those metals taken from the samples of Asian side.

Storelli *et al.* (2000) observed, the average concentrations of the heavy metals found in mussels samples were 0.64 ppm for Cd and 1.19 ppm for Pb. And he suggests that these values are below acceptable levels for human consumption. We have found the concentrations of cadmium and lead in mussels higher than Storelli's investigation. Phillips and Rainbow (1994), observed a weight-dependant variation in concentrations of metals in *Mytilus edulis*, in the environment, smaller and lighter individuals were found to contain significantly higher concentrations of Zn, Cd, Pb and Cu than larger and heavier individuals. Our results don't support these findings. We have founded higher concentrations in big mussels and lesser concentrations in small molluscs. Pollution in Bosphorus attracts the attention of many investigators. In a study by Atayeter (1991), accumulation of heavy metals such as Fe, Cu, Zn, Pb and Al has been investigated in the gills and digestive glands of the mussels (*Mytilus galloprovincialis*) taken from Anadolu Kavağı area in Bosphorus. It has been observed that in the months of August, September and October the most accumulated metal was zinc, followed by Fe, Cu and Al. In January and February the most accumulated metal was lead.

Şentürk (1993) found Hg, Cd and 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. This study was done more than one decade ago. Our results have shown a more severe pollution when compared with it. Although the civil authorities and city municipality spends remarkable effort to stop the pollution, our study shows that this problem and its potentially harmful effects still continues. Bat *et al.* (1999) found an interesting result when they studied with the molluscs of Sinop, Black sea. They have found the concentrations of Cu, Zn, Cd and Pb in the *Mytilus galloprovincialis* from Sinop within the normal ranges for our country's acceptable limits. Bat *et al.* indicated the highest concentrations of all heavy metals studied were well below the permitted levels. Bat *et al.* (1999) also observed, from the public health point of view, the levels of copper, zinc, lead and cadmium levels found in his study were generally inside the acceptable levels. These results conflict with our findings. We have founded the highest levels of cadmium and lead 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.

CONCLUSIONS

The concentrations of cadmium and lead in the Mediterranean mussels from 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 cadmium and lead when compared with the previous studies. The major findings of this study are that cadmium and lead 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 cadmium and lead levels 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 levels of the metals found in this study were generally higher than the permitted levels and those of previous studies.

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