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ACCUMULATION OF CADMIUM AND LEAD IN COMMERCIALLY IMPORTANT FISH SPECIES IN THE GULF OF GEMLİK, MARMARA SEA, TURKEY

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Abstract

The aim of this study was to investigate the concentrations of cadmium (Cd) and lead (Pb) in gill and muscle tissues of ten commercial fish caught from the Gulf of Gemlik, Marmara Sea, Turkey. Ten commercially important marine fish species were obtained monthly from the local fishermen. The Cd and Pb levels in muscle and gill tissues of the fish samples were evaluated using atomic absorption spectrophotometer (Shimadzu 6701, Shimadzu, Tokyo, Japan). In July 2011, the highest concentrations of Cd were found in the gill tissue of *Sardinella maderensis, Solea vulgaris* and *Belone belone* (3.62, 3.46 and 3.05µg g^{-1}, respectively). In March 2011, the highest concentrations of lead were observed in the gill tissues of *S. vulgaris* and *B. Belone* (9.48 and 6.74 µg g^{-1}, respectively), and the muscle tissue of *S. maderensis* (7.07 µg g^{-1}). Generally, the levels of Cd and Pb were found very high for the than the tolerance limits of Turkish Food Codex, European Union (EU) and the World Health Organization (WHO) standards.

INTRODUCTION

Fish are an important protein sources for human health because of having rich contents of essential minerals, vitamins and unsaturated fatty acids (Zaza et al. 2015). The concentrations of heavy metals in seawater, sediments and aquatic organisms such as fish, have been investigated all around the world. Heavy metals are present in the aquatic environment as results of industrial, agricultural and mining activities, etc. The heavy metals can accumulate in the living organisms and thus in the food chain. But the presence of heavy metals in seawater and aquatic products not only threatens aquatic organisms but also may affect human health via the food chain (Scudiero et al. 2014; Gu et al. 2015). The bioaccumulation of heavy metals occur in the various tissues in fish, therefore, may become toxic for public health. Cd and Pb are biologically non-essential metals for living organisms. On the contrary, these metals can damage gills and have negative effects on respiratory and osmoregulation functions of fish. Furthermore, their toxicity rises with increasing concentrations (Bat et al. 2012).

Gulfs of seas are considerable ecosystems of great ecological importance to aquatic habitats because of its biodiversity. Many migratory or nonmigratory aquatic species use gulfs as habitats during any part of their life cycles such as spawning, breeding, and feeding. But these ecologically and economically important aquatic habitats have been contaminated by various pollutants such as heavy metals. The Gulf of Gemlik is located in the Southeastern part of the Marmara Sea. Four big Seaport and harbour areas are situated in the Gulf of Gemlik such as Gemport Harbour, Gemlik Harbour, Borusan Harbour and TUGSAS Harbour (Dogan and Burak, 2007; Guven et al. 2010). In addition to, there are agricultural and various industrial activities in Gemlik Gulf. The purpose of this work is a determination of cadmium and lead levels in muscle and gill tissues of ten commercially important fish species from the Gulf of Gemlik (Marmara Sea, Turkey).

MATERIAL AND METHOD

Study Area

The Marmara Sea and Gulf of Gemlik are semi-enclosed water. The Gulf of Gemlik is an inlet of the Marmara Sea in the Marmara Region, Turkey. The Gulf is located in the Southwestern side of the Marmara Sea (Figure 1). Four big Seaport and harbour area are situated in the Gulf of Gemlik such as Gemport Harbour, Gemlik Harbour, Borusan Harbour and TUGSAS Harbour. In addition to, there are various agricultural and industrial activities in Gemlik region.

Samples Collection and Experimental Design

Selected ten fish species are: *Mullus barbatus barbatus* (Red mullet), *Solea vulgaris* (Common sole), *Atherina boyeri* (Big-scale sand smelt), *Engraulis encrasicolus* (European anchovy), *Trachurus mediterraneus* (Atlantic horse mackerel),

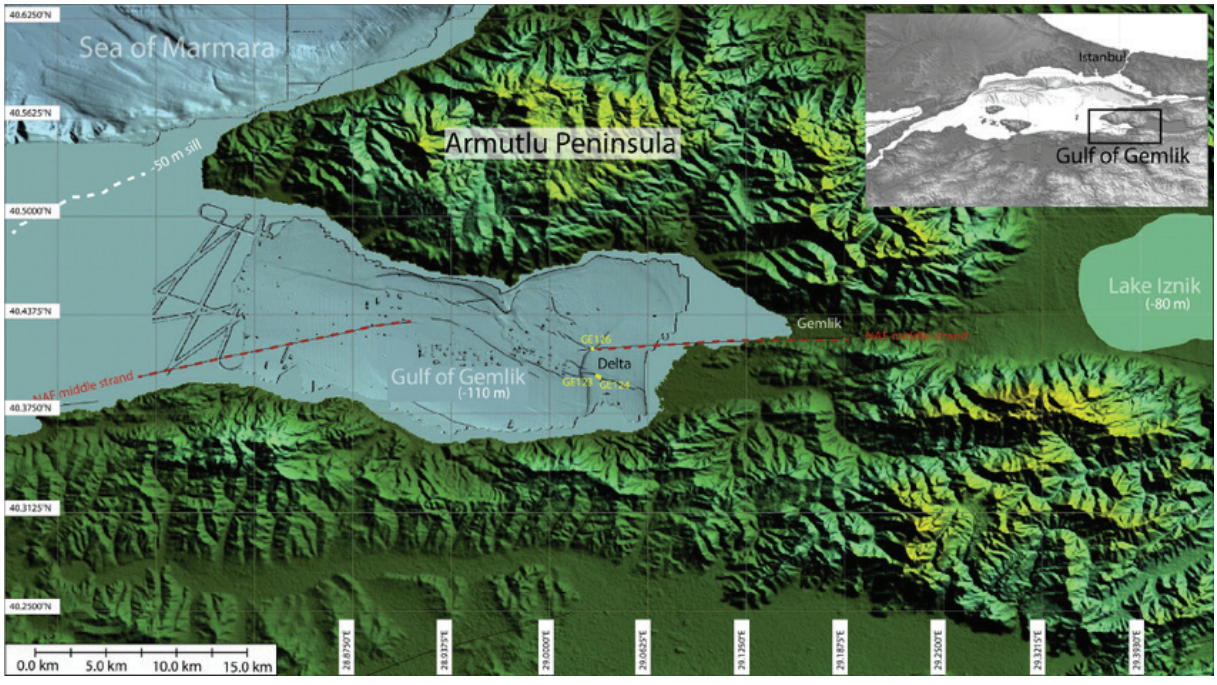

Figure 1. The study area of the Gulf of Gemlik, Marmara Sea, Turkey.

Spicara maena maena (Blotched picarel), *Trigla lucerna* (Tub gurnard), *Merlangius merlangius euxinus* (Black Sea whiting), *Sardinella maderensis* (Madeiran sardinella) and *Belone belone* (Garfish) (Fishbase, 2016). All fish collected randomly in March 2011 and March 2012 from Gulf of Gemlik of Marmara Sea. Fish samples were rinsed in clean water and labeled, packed in polyethylene bags and stored in freezers until heavy metal analysis. After collection, muscle and gill tissues of fish species dissected according to UNEP (UNEP 1991). The tissues homogenized in a blender. Approximately 6-8 g of homogenate digested with 5:3 HNO_3:H_2SO_4 in microwave digestion system. Then diluted to the last volume with 1N HNO_3. All analyses were studied using an atomic absorption spectrophotometer (AAS) (Shimadzu 6701; Shimadzu, Tokyo, Japan). In this study the detection limits for Cd and Pb were; Cd: 0.10 and Pb 0.10 mg l^{-1}respectively according to Turkish Food Codex (Anonymous, 2006) and WHO (WHO, 1995). The reference materials for the accuracy and precision of tests (IAEA-MEL, IAEA436 and IAEA433) was given in Table 1. The analytical precision of the tests was better than 10% at 95% significance levels from five replicates.

Table 1. Accuracy of AAS analyses used in this study as determined by analysis of reference materials (the RSD of measured values were ≤7%). ([a,b*]IAEA-MEL Reference samples for laboratory. AAS: atomic absorption spectrophotometry; Pb: lead; Cd: cadmium; IAEA-MEL: International Atomic Energy Agency-Monaco Environment Laboratoires).

Reference material	Element	Measured value (this study) (µg/g^{-1})	Certified value or range (µg/g^{-1})
*IAEA 433a	Pb	76.9	72.6-77
*IAEA 436b	Cd	0.153	0.145-0.161

Statistical Analysis

The Statistical Package for the Social Sciences 23.0 (IBM Corp.; Armonk, NY, USA) package program was used for statistic analysis, study data were given as arithmetic means and standard deviations. A value of $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

The mean levels of Cd and Pb in muscle and gill tissues of the selected commercial ten fish species are given in Table 2 for each heavy metal, respectively. In this study, Cd levels generally were determined as higher than the acceptable legal limits (Table 2) set by the Turkish Food Codex (0.1 µg g^{-1}) (Anonymous, 2006). Pb concentrations were found higher than the acceptable legal levels (Table 2) according to the TFC for Aquatic Products (1.0 µg g^{-1}) (Anonymous, 2006). Also, EU has set acceptable limits for cadmium and lead concentrations in the muscle tissue of fish intended for human consumption as 0.1 Cd and 1.0Pb µg g^{-1} ww, respectively (Anonymous, 2008). Fish can absorb Cd and Pb mainly through gills, digestive

Table 2. The mean values of Cd and Pb concentrations in the muscle and gill tissue of ten species from the Gulf of Gemlik. (Cd: Cadmium; Pb: lead; n: samples number; SD: standard deviation).

		Cd (Mean values±SD) µg g^{-1}		Pb (Mean values±SD) µg g^{-1}	
Species	**n**	**Muscle**	**Gill**	**Muscle**	**Gill**
Mullus barbatus	35	1.01±1.16	1.00±1.16	1.05±1.10	2.60±1.10
Solea vulgaris	28	1.01±1.01	3.50 ±1.10	1.15±1.16	9.48±1.16
Atherina boyeri	29	1.12±1.10	2.70±1.02	1.32±1.02	3.10±1.10
Engraulis encrasicolus	90	1.10±1.02	1.65±1.16	1.45±1.10	2.55±1.16
Trachurus mediterraneus	50	1.00±1.02	1.80±1.10	3.12±1.16	1.10±1.02
Spicara maena	33	1.10±1.02	1.50±1.10	1.40±1.02	3.50±1.05
Tropheops lucerna	25	1.00±1.15	1.35±1.02	2.11±1.10	7.47±1.16
Merlangius euxinus	37	1.00±1.15	1.00±1.16	2.80±1.16	1.30±1.16
Sardinella maderensis	25	1.15±1.02	3.70±1.16	7.80±1.16	2.41±1.10
Belone belone	31	1.00±1.01	3.00±1.10	2.50±1.10	6.80±1.16
Aquatic products directory			Cd: 0.1 µg g^{-1}		Pb: 1.0 µg g^{-1}

systems and skin thus Cd and Pb accumulate in the tissues and organs of fish. Among the metals that generate concern for their environmental exposition, via food, are found Pb, Cd and Hg. Pb which is persistent heavy metal has been characterized as a priority hazardous substance (IARC 1993).The most toxic form in water is evaluated to be the free Pb^{2+}ions (Monteiro et al. 2011). Although Pb is a naturally occurring substance, its environmental concentrations can significantly increase by anthropogenic activities such as mining, battery manufacturing etc. in the aquatic environments. Aquatic organisms can accumulate lead from seawater and also from their diet (Creti et al. 2010).

Aquatic pollution studies attract the attention of many investigators (Balkıs et al. 2013; Chahid et al. 2014; Makedonski et al. 2015; Araujo and Cedeno-Macias 2016). Determination of trace metal accumulation in various fish species from seas, lakes, rivers, and reservoirs have largely been conducted in food safety studies. It is well known that heavy metals such as Cd and Pb, are potentially accumulated in marine organisms and sediments where they subsequently transferred to man through the food chain (Unlu et al 2008; Aksu et al. 2011; Jayaprakash et al. 2015). We found the levels of cadmium and lead in fish species were generally higher than Turkish legal standards (Anonymous, 2008). Chahid et al. (2014) determined the mean levels of Cd and Pb found in fish from Atlantic Sea (Morocco) as 0.009-0.036 µg g^{-1} for Cd and 0.013-0.014 µg g^{-1} for lead. Authors suggest that these values were below acceptable levels for human consumption and thus cause no health problems for consumers. For the fish samples from the Black Sea, Bat et al. (2012) had been detected Pb and Cd levels lower than the recommended legal limits for human consumption according to the Turkish Food Codex (Anonymous, 2008). We found the levels of cadmium and lead in fish tissues higher than Chahid's and Bat's studies. Atobatele et al. (2015), reported the concentrations of Cd and Pb levels in kidney, liver, gill, intestine, and muscle of fish species from Aiba Reservoir, Nigeria. Authors found that the levels of heavy metals; 0.001 to 0.100 µg g^{-1} Cd and 0.001-0.125 µg g^{-1} Pb for dry weight respectively (Atobatele et al. 2015). Our results didn't support these findings. We found highCd and Pb levels in gills and muscle tissues of fish in our study. In a study by Frantzen et al. (2015) accumulation of heavy metal such as Cd and Pb have been investigated in the muscle tissue of the *Clupea harengus* caught from the Norwegian Sea. It was reported that Cd and Pb levels in muscle tissue of fish were 0.010±0.006 µg g^{-1} Cd and <0.01±0.10 µg g^{-1} respectively. At the same time, Cd and Pb concentration have been increased with increasing fish age in their study. Cd and Pb have evaluated threats to human health due to their highly toxic effects when absorbed by aquatic organisms. The risk of metal toxicity is detected by the levels of the heavy metals in edible tissues and amount of fish consumed (Ordiano-Flores et al. 2011). Araujo and Cedeno-Macias (2016) investigated Cd and Pb levels in liver and muscle tissue of yellowfin tuna (*Thunnus albacares*) caught from other areas of the Ecuadorian coasts. In the analysis of the samples for Cd, the average values they were found higher than the permitted limit but lead levels were found in acceptable limits in the muscle tissue of yellowfintuna. Olmedo et al. (2013) investigated the levels of cadmium and lead in the fish and shellfish samples from Andalusia (Southern Spain). They found in their study the levels of cadmium and lead levels were generally higher than the acceptable concentrations. Their conclusion conflict with our results. Tuzen (2009) reported higher Cd concentrations in fresh anchovy and scad (0.27 and 0.32 µg g^{-1} ww, respectively) caught from the Black Sea, Turkey. We compared this study with the other studies and we found harmful effects for the gulf.

CONCLUSIONS

The levels of Cd and Pb in our commercial fish samples from four locations of the Gulf of Gemlik were determined by AAS for analysing cadmium and lead pollution. Cadmium and lead levels were found higher than the acceptable levels set by the Turkish Food Codex, EU and WHO for aquatic products in various aquatic species. Also, our results showed higher levels of Cd and Pb when compared with the present studies. From the human health point of view, the concentrations of cadmium and lead found in this work were usually higher than the permitted concentrations and those of previous studies.

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