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Fahri Karayakar - Sahire Karaytug - Bedii Cicik - Cahit Erdem - Özcan Ay - Nuray Ciftci

PSP
Angerstr. 12
85354 Freising - Germany
Phone: ++49 – (0) 8161-48420
Fax: ++49 - (0) 8161-484248
Email: parlar@psp-parlar.de
www.psp-parlar.de

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HEAVY METAL LEVELS IN FIVE SPECIES OF FISH CAUGHT FROM MERSIN GULF

Fahri Karayakar[1], Sahire Karaytug[1], Bedii Cicik[1]*, Cahit Erdem[2], Özcan Ay[1] and Nuray Ciftci[1]

[1] University of Mersin, Faculty of Aquaculture, Yenişehir Kampüsü, C Blok, Kat 2, 33169 Mersin, Turkey
[2] University of Çukurova, Faculty of Art and Sciences, Biology Department, 01330 Balcalı, Adana, Turkey

ABSTRACT

The aim of the present study was to determine the levels of cadmium, copper, zinc and chromium in the liver, gill and muscle tissues of some pelagic, benthopelagic and benthic fish species caught from Mersin Gulf and sold at Karaduvar Harbor. Pelagic species *Sardinella aurita* (Clupeidae), *Liza ramado* (Mugilidae), benthopelagic species *Diplodus annularis* (Sparidae) and benthic species *Solea lutea* (Soleidae) and *Umbrina cirrosa* (Sciaenidae) were selected as the study material. Atomic absorption spectrophotometric methods were applied in determining the tissue levels of metals.

Metal levels showed tissue-dependent changes in the species studied. Pb and Cr levels were below detection limit; hence no comparison was made among the tissues. Cd, Cu and Zn levels were highest in the liver tissues and lowest in the muscle tissues of the species studied, except *S. aurata*. Gill Zn and Cd levels exceeded the liver and muscle levels in this species. Metal levels were higher in pelagic species compared with benthic ones.

KEYWORDS: heavy metal, accumulation, Mersin Gulf, fish, pelagic, benthic

INTRODUCTION

Heavy metals enter aquatic environments through a number of natural events, such as rain, wind, erosion and volcanic activities at low levels. Their levels, however, elevated considerably as a result of releasing untreated domestic, industrial and agricultural wastewaters to these environments in recent years [1].

Heavy metals, such as copper, zinc and iron, are necessary in trace amounts for vital functions and those, such as mercury, cadmium and lead, have no known functions in metabolic activities. The entrance of these metals into aquatic environments at low concentrations results in accumulation, mainly in metabolically active tissues as well as death or habitat changes at higher concentrations [2].

Determination of heavy metal levels in economically important fish species is vital in assessing the risk of heavy metal toxicity to human since these metals get more concentrated at successive rings of the food chain [3]. Hence, fish species that are consumed in the region and differed in their habitats and feeding habits are chosen as the study material.

Although heavy metals are taken through water, food and absorption through gills and the whole body, they accumulate mainly in metabolically active organs independent of the uptake route [4]. Gills form the main target organ for heavy metal toxicity since they are in direct contact with the toxicants as the water flows through gill lamella [5]. The liver plays a role in transformation of nutrient components, and detoxification and storage of toxic materials [6]. Muscle tissue is not an active tissue in binding metals but plays an important role in passing the metals to higher trophic levels via the food chain since it forms the main edible part. Tissue accumulation of heavy metals in fish mainly depends on the availability of the metal in the environment; hence, determination of metals in fish tissue is important in reflecting the environmental metal pollution [7].

Mersin coastline, placed at the Eastern Mediterranean coast of Turkey, has a high pollution risk due to overpopulation and excessive agricultural and industrial activities. The elevated metal levels found in some fish species were associated with the high pollution burden of the environment [8].

Study of heavy metal accumulation in fish, which form the top ring of the food chain in aquatic systems and were consumed by humans as a protein source, not only reflects pollution status of the environment in concern, but also is important as far as the human health is concerned. Hence, in the present study, heavy metal levels in tissues of 5 economically important fish species were determined caught from Mersin Gulf and sold at Karaduvar Harbor.

MATERIALS AND METHODS

Economically important 5 fish species, namely, *S. lutea*, *U. cirrosa*, *D. annularis*, *L. ramado* and *S. aurata*, were used as study materials. These species of fish were chosen since they all are consumed as a protein source, and they occupy different habitats in the water column.

Samples were obtained from fishermen fishing in Mersin Gulf and marketing their harvest at Karaduvar Harbor during 2007-2008 fishing season (Fig. 1). Fifteen fish samples were taken from each species studied and brought to Mersin University, Faculty of Aquaculture, Basic Sciences Laboratory, under cold transfer conditions. Since heavy metal accumulation changes depending on the size and weight in fish [9], these parameters for each species were determined and given in Table 1.

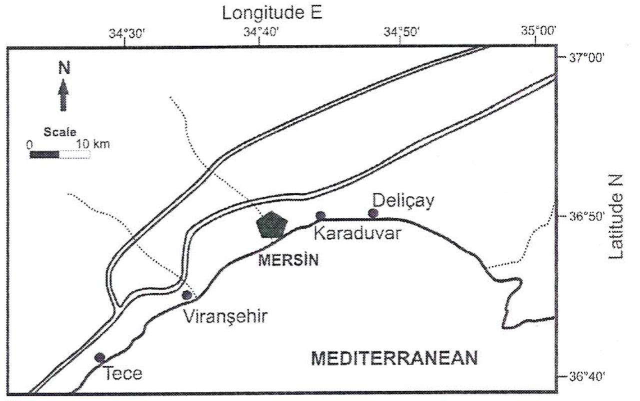

FIGURE 1 – Map of the study area (Mersin Gulf)

TABLE 1 - Mean length and weight measurements of the species studied.

Species	Length (cm)	Weight (g)
	$\overline{X} \pm S_{\bar{x}}$	$\overline{X} \pm S_{\bar{x}}$
Solea lutea	20.94 ± 0.23	72.20 ± 1.13
Umbrino cirrosa	22.48 ± 0.44	127.03 ± 2.22
Diplodus annularis	15.75 ± 0.18	65.43 ± 1.88
Liza ramado	26.71 ± 0.19	155.26 ± 5.31
Sardinella aurita	14.84 ± 0.13	21.55 ± 0.66

$\overline{X} \pm S_{\bar{x}}$ = Mean ± Standard error

Gill, liver and muscle tissues were dissected from each specimen. Tissue samples were placed in Petri dishes and dried at 105 °C for 72 h [10]. After determining their dry weights, tissues were transferred to glass tubes and 2 ml nitric acid and 1 ml perchloric acid 2:1 v/v (Merck) was added for 8-h wet digestion at 120 °C [10].

The samples were then transferred to polyethylene tubes and their total volume was made up to 5 ml by adding deionized water. Levels of Cd, Cr, Cu, Pb and Zn in the tissues were determined using atomic absorption techniques (AAS; GBC 933 AA). Statistical analysis of the data was carried on using Student Newman Keuls' Procedure [11].

RESULTS

The means of Cu, Zn, Cd, Cr and Pb levels in gill, liver and muscle tissues of the species studied are given in Table 2, together with the results of statistical analysis.

The levels of lead and chromium were below detection limits at all the tissues and species studied, hence no data were given for these metals. Copper levels showed differences between the species at any given tissue ($P< 0.05$), whereas zinc levels showed significant differences in pelagic species compared with the benthic and benthopelagic species ($P<0.01$). There was no difference in the tissue levels of cadmium among the species ($P>0.05$), except the gill tissue.

Tissue metal levels in the species studied are given in Figures 1, 2 and 3 for copper, zinc and cadmium, respectively.

The following relationship was found among the tissues in accumulating metals (except Zn in *S. aurata* and Cd in *D. annularis):* Liver>Gill>Muscle.

TABLE 2 - Heavy metal levels in gill, liver and muscle tissues of the species studied (µg metal/g d.w.).

Species**	Tissue	Cu	Zn	Cd
		$\overline{X} \pm S_{\bar{x}}$ *	$\overline{X} \pm S_{\bar{x}}$ *	$\overline{X} \pm S_{\bar{x}}$ *
LR	Gill	5.88 ± 0.15 a	25.48 ± 0.89 a	1.04 ± 0.03 a
DA		2.57 ± 0.10 b	18.14 ± 0.62 b	1.18 ± 0.05 ba
SL		4.87 ± 0.30 c	21.71 ± 0.52 c	0.78 ± 0.06 c
SA		4.21 ± 0.17 d	53.53 ± 1.05 d	1.24 ± 0.05 db
UC		1.68 ± 0.26 e	16.77 ± 0.74 b	0.38 ± 0.03 e
LR	Liver	40.05 ± 1.93 a	61.16 ± 2.05 a	2.01 ± 0.99 a
DA		9.25 ± 0.67 b	53.52 ± 1.05 b	1.04 ± 0.06 b
SL		25.88 ± 1.33 c	34.06 ± 1.05 c	1.10 ± 0.08 b
SA		23.93 ± 1.47 c	37.76 ± 0.94 c	2.36 ± 0.13 c
UC		4.64 ± 0.46 d	29.00 ± 1.74 d	0.92 ± 0.04 b
LR	Muscle	3.41 ± 0.06 a	15.78 ± 0.44 a	0.73 ± 0.04 a
DA		1.52 ± 0.05 b	2.36 ± 0.06 b	0.20 ± 0.01 b
SL		1.74 ± 0.07 c	11.60 ± 0.40 c	0.20 ± 0.01 b
SA		2.33 ± 0.05 d	15.37 ± 0.51 a	0.27 ± 0.03 b
UC		1.06 ± 0.07 e	9.78 ± 0.45 d	0.35 ± 0.02 c

* Letters were used to show differences among species. Data shown with different letters are significant at the $P<0.05$ level. $\overline{X} \pm S_{\bar{x}}$ = mean ± standard error; ** LR: *Liza ramado*; DA: *Diplodus annularis*; SL: *Solea lutea*; SA: *Sardinella aurita*; UC: *Umbrino cirrosa*

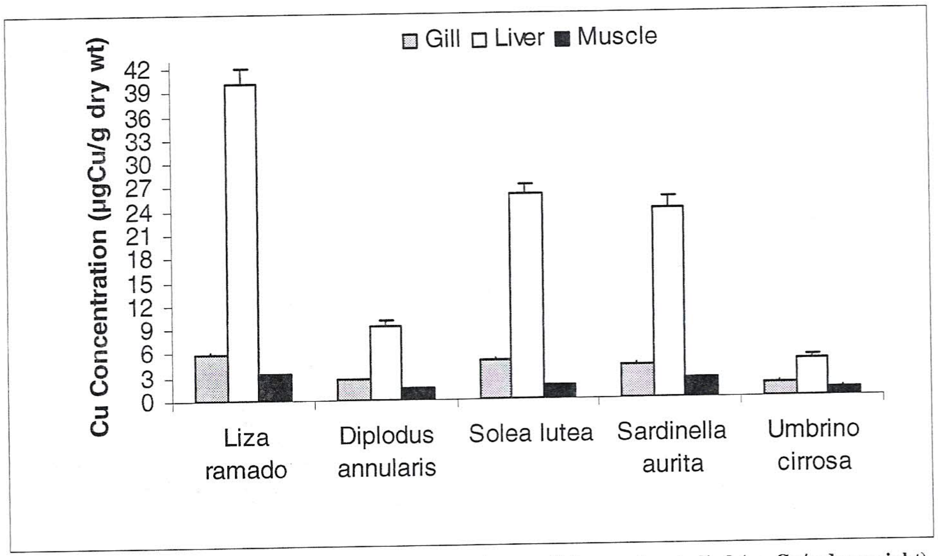

FIGURE 2 - Copper levels in gill, liver and muscle tissues of the species studied (µg Cu/g dry weight).

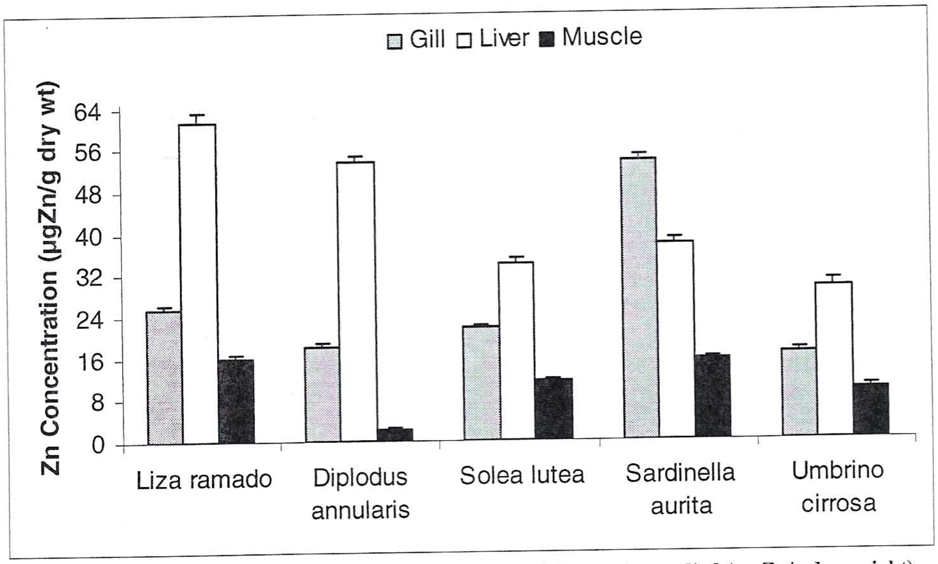

FIGURE 3 - Zinc levels in gill, liver and muscle tissues of the species studied (µg Zn/g dry weight).

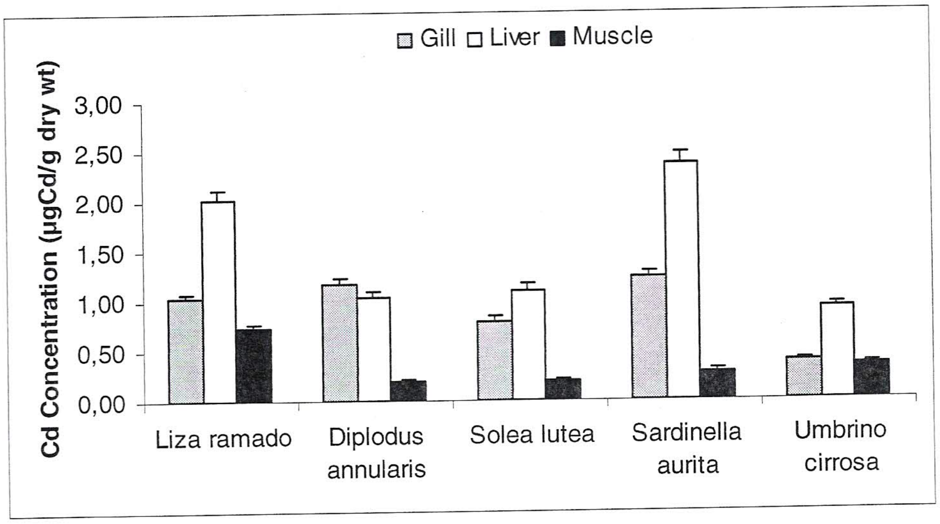

FIGURE 4 - Cadmium levels in gill, liver and muscle tissues of the species studied (µg Cd/g dry weight).

Metal levels at all the three tissues studied were higher in pelagic species compared with the benthic and benthopelagic species.

DISCUSSION

Heavy metals taken by aquatic organisms through various pathways, accumulate in tissues when excretion does not compensate uptake ratio, and when the tissue carrying capacity is exceeded, it results in mortality [12]. Heavy metal accumulation in fish depends on species [13], tissue in concern, the type and concentration of metals, and exposure period [14]. It also depends on feeding habits of the fish, physical and chemical properties of water [15], other metals [16, 17] and complexing agents [18] present in the medium.

It was shown that heavy metal levels show interspecies differences in nature studies carried out with freshwater [13, 18] and marine fishes [9, 19, 20-22].

Cu, Pb and Cd levels in tissues of *Capoeta capoeta* were higher than those in *Cyprinus carpio* sampled from River Berdan – Mersin [13], and Fe, Cu, Ni, Cr, Pb and Zn levels in tissues of *Mugil cephalus* were higher than that of *S. aurata* sampled from İskenderun Bay [21] which was suggested to be due to the differences in feeding habits of the mentioned species.

Cd, Pb, Cu, Cr, Ni, Zn and Fe levels in *M. cephalus*, *Mullus barbatus* and *Caranx crysos* sampled from the North-East Mediterranean, although their ecological needs differ, were found to be rather high, reflecting elevated levels of heavy metal pollution in the area [8]. Levels of Fe, Cu, Ni, Cr, Pb and Zn in tissues of *M. cephalus* and *Trachurus mediterraneus* differed significantly although both are pelagic species [23].

The results of the present study, carried out with 5 species of fish, revealed that Cu, Zn and Cd levels in tissues of pelagic species were higher compared with the benthic species which might result from differences in their ecological needs, behavior, or from the different pollution state of their environments.

Tissue accumulation of heavy metals is closely related to the metabolic activity of the tissue in concern. Studies carried out with different species of fish showed that metal accumulation is higher in tissues, such as liver, gill and kidney, compared to muscle [4, 6]. Cd, Cr, Cu, Fe, Pb and Zn levels were higher in liver and gill compared with the muscle tissues of 6 different fish species collected from Mersin, Karataş and İskenderun Bays which was suggested to be due to differences in metal binding protein synthesis capacity of these tissues [9]. The levels of cadmium were higher in liver than muscle tissues of *M. barbatus* and *S. aurata* collected from Mersin Bay [20]. Copper, zinc and cadmium levels in liver and gill tissues were also found to be higher than in muscle tissues of the 5 species studied, having different ecological and feeding habits. These differences among the tissues in accumulating metals might be due to different metabolic activities and metal binding protein synthesis capacity of the tissues studied.

As far as the fish and human health is concerned, it is important to determine the heavy metal levels in muscle tissue, since it forms the main edible part. Although acceptable levels of heavy metals in edible tissues for human consumption differ between various institutions, according to Turkish Food Codex, predicted levels for Cd, Zn and Cu are 0.1 μg/g, 50 μg/g and 20 μg/g, respectively, on wet weight basis.

Cadmium levels were found to be higher than the acceptable levels in the muscle tissues of *M. barbatus* and *S. aurata* collected from Mersin Bay [20]. Levels of Cu and Zn were within the acceptable limits in the muscle tissues of these two species whereas the levels of Pb and Cd were found to be higher than the predicted ones in a study carried out with the same species from Iskenderun Bay [19]. Similar results were obtained in the present study carried out in Mersin Bay (levels of Cu and Zn being in the acceptable range, and that of Cd exceeding the predicted levels).

It was concluded that the levels of Cu, Zn and Cd in liver, gill and muscle tissues were dependent upon the species and the tissues in concern, and that the muscle levels of cadmium exceeded the acceptable levels in the 5 species studied caught from Mersin Bay. Differences in habitat and feeding habits among the species studied might be the possible cause for interspecies differences, and metabolic activity might be the reason for the differences among the tissues. High levels of cadmium were found in muscle tissues, and reflect Cd pollution in the environment.

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CORRESPONDING AUTHOR

Bedii Cicik
University of Mersin
Faculty of Aquaculture
Yenişehir Kampüsü
C Blok, Kat 2
33169 Mersin
TURKEY

E-mail: bcicik@mersin.edu.tr

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