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COMPARISON OF THE HEAVY METAL CONCENTRATIONS IN ATLANTIC HORSE MACKEREL, *TRACHURUS TRACHURUS*, FROM COASTAL WATERS OF TURKEY

Cengiz Mutlu[1], Aysun Türkmen[2], Mustafa Türkmen[1], Yalçın Tepe[1,*] and Alpaslan Ateş[3]

[1] Giresun University, Faculty of Science and Arts, Department of Biology, 28049, Giresun, Turkey
[2] Giresun University, Faculty of Science and Arts, Department of Chemistry, 28049, Giresun, Turkey
[3] Rize University, Maritime School, Department of Maritime Transportation and Management Engineering, Derepezarı 53900, Rize, Turkey

ABSTRACT

The concentrations of cadmium, iron, lead, zinc, copper, manganese, nickel, chromium and cobalt were determined by ICP-AES in muscles and livers of Atlantic horse mackerel, *Trachurus trachurus*, from coastal waters of Turkey. The analyzed fish samples were collected from different locations in the Black, Marmara, Aegean and Mediterranean seas. The heavy metal concentrations in tissues were significantly affected by sampling sites ($p< 0.05$). Iron showed the highest levels in both tissues from all locations, followed by Zn. In all locations, the heavy metal concentrations in livers were higher than those in muscles. In addition, the differences between the heavy metal concentrations in tissues were statistically significant ($p<0.05$). Heavy metal levels in tissues were compared with national and international permissible limits. Heavy metal concentrations in the edible parts of fish were assessed for human uses.

KEYWORDS:
Heavy metals, *Trachurus trachurus*, fish, Turkey waters

1. INTRODUCTION

Industrial wastes, geochemical structure and mining of heavy metals create a potential source of heavy metal pollution in the aquatic environment [1, 2]. Under certain environmental conditions, heavy metals might accumulate up to toxic concentrations and cause ecological damage [3, 4]. Therefore, numerous studies have been carried out on heavy metal accumulation in different fish [5-9]. On the other hand, fish have been popular targets of heavy metal monitoring programs in marine environments because sampling, sample preparation and chemical analysis are usually simpler, more rapid and less expensive than alternative choices, such as water and sediments [10]. Our specific objectives were to determine the distribution of analyzed heavy metals in muscles and livers of *Trachurus trachurus* from the coastal waters of Turkey, to evaluate the differences between the heavy metal levels in different sites, and to compare the results with national and international permissible concentrations.

* Corresponding author

2. MATERIALS AND METHODS

Fish samples were obtained from commercial fishing efforts of local fishermen from along six different sites in the coastal waters of Turkey, from November 2004 to March 2005. These sampling sites were SNP and BRT in the Black Sea, YLV in the Marmara Sea, NAS and CAS in Aegean Sea, and IB in Mediterranean Sea (Fig. 1). Specimens obtained during the sampling period were brought to laboratory on ice. Total length and weight of the samples were measured to the nearest mm and g before dissection. Approximately 0.5-g samples of muscle and entire liver (for small fish, the livers of 2-4 samples were pooled) from each fish were dissected, washed with distilled water, weighed, packed in polyethylene bags and stored at -18 ^{o}C, prior to analysis.

All tissue samples were transferred into 100-ml Teflon beakers. Thereafter, 10 ml ultra-pure concentrated nitric acid was added slowly to the sample. The Teflon beaker was covered with a watch glass, and heated at 200 ^{o}C on a hot plate for 3 h, to evaporate the solution slowly to near dryness. Two ml of 1 N HNO_3 was added to the residue, and the solution was evaporated again on the hot plate. By repeating the additional digestion twice, all organic materials in each sample were completely digested. After cooling, 2.5 ml of 1 N HNO_3 was added to the digested residue, transferred to 25-ml volumetric flasks, and then diluted to level with deionized water. Before analysis, the samples were filtered through a 0.45-μm nitrocellulose membrane filter. Sample blanks were prepared in the

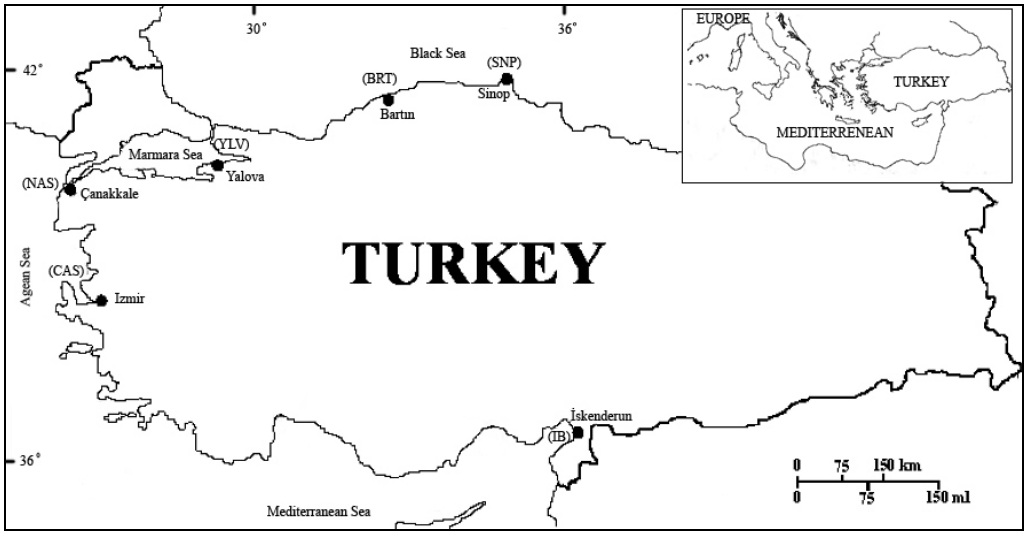

FIGURE 1 - The sampling locations from the coastal waters of Turkey (SNP: Sinop, BRT: Bartın, YLV: Yalova, NAS: North Aegean Sea, CAS: Central Aegean Sea, IB: İskenderun Bay).

laboratory in a similar manner to the field samples [5]. Metal contents were expressed as μg g^{-1} wet weight for tissues. All samples were analyzed three times for Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn by ICP-AES (Varian Liberty Series-2). Standard solutions were prepared from stock solutions (Merck, multi element standard). The accuracy and precision of our results were checked by analyzed certified reference material (CRM, Dorm-2). The results showed good agreement between the certified and the analytical values, and the recovery of elements ranged from 93 to 109%. To test the differences between the concentrations in tissues of the samples from different sites, one-way ANOVA and following post-hoc test (Duncan) were performed with SPSS 13.0 for Windows.

3. RESULTS AND DISCUSSION

The mean heavy metal concentrations in the tissues of Atlantic horse mackerel, *Trachurus trachurus,* from different locations in the coastal waters of Turkey are presented in Table 1. Iron had the highest levels in both tissues, followed by zinc at all locations. Copper generally showed the third-highest levels, except Ni in liver from SNP, and Mn in muscle from BRT. On the other hand, cadmium showed the lowest levels in both tissues from all locations, especially in YLV and NAS. Cobalt had the second-lowest levels, in agreement with the results of many researchers [6, 8, 11]. In addition, the heavy metal concentrations in livers were higher than those in muscles from all locations. This situation is in agreement with the results of many researchers [5, 8, 12-14].

TABLE 1 - Mean heavy metal concentrations with SE in the tissues of *T. trachurus* from the coastal waters of Turkey and comparison of different sites (μg g^{-1} wet wt)*.

		Sites					
H.M.	T.	SNP	BRT	YLV	NAS	CAS	IB
Cd	M.	0.03±0.00^{ab}	0.08±0.01^{c}	<0.01^{a}	<0.01^{a}	0.05±0.02^{b}	0.03±0.00^{ab}
	L.	0.09±0.02^{b}	0.19±0.03^{b}	0.04±0.01^{a}	0.05±0.01^{a}	0.10±0.03^{b}	0.11±0.03^{b}
Co	M.	0.07±0.01^{b}	0.08±0.01^{b}	0.05±0.01^{b}	0.16±0.03^{a}	0.04±0.01^{b}	0.03±0.01^{b}
	L.	0.16±0.03^{ab}	0.41±0.02^{ab}	0.11±0.04^{a}	0.41±0.05^{ab}	0.64±0.22^{b}	0.20±0.07^{ab}
Cr	M.	0.20±0.09^{a}	0.16±0.06^{a}	0.07±0.02^{a}	0.08±0.02^{a}	0.13±0.03^{a}	0.22±0.02^{a}
	L.	0.46±0.12^{ab}	0.83±0.09^{b}	0.14±0.08^{a}	0.63±0.09^{ab}	0.84±0.14^{b}	1.02±0.32^{b}
Cu	M.	1.17±0.12^{bc}	0.82±0.09^{abc}	0.56±0.15^{ab}	1.03±0.32^{abc}	0.48±0.12^{a}	1.30±0.22^{c}
	L.	1.31±0.28^{b}	20.5±2.54^{a}	1.33±0.14^{b}	16.7±2.60^{a}	6.13±1.69^{b}	3.73±0.38^{b}
Fe	M.	24.9±5.09^{ab}	28.0±1.59^{ab}	39.4±13.3^{bc}	52.3±2.88^{c}	29.9±5.08^{ab}	19.3±2.32^{a}
	L.	165±42.34^{ab}	76.7±9.89^{a}	102±21.1^{a}	93.1±8.00^{a}	308±89.9^{b}	182±37.9^{ab}
Mn	M.	0.39±0.08^{ab}	0.86±0.05^{c}	0.19±0.09^{a}	0.64±0.16^{bc}	0.21±0.04^{a}	0.30±0.06^{a}
	L.	1.12±0.10^{ab}	2.11±0.17^{c}	0.46±0.12^{a}	1.29±0.19^{abc}	1.94±0.45^{bc}	0.86±0.14^{a}
Ni	M.	0.83±0.24^{bc}	0.27±0.02^{ab}	0.06±0.01^{a}	1.03±0.19^{c}	0.46±0.17^{abc}	0.44±0.13^{ab}
	L.	3.97±0.53^{d}	0.77±0.12^{ab}	0.16±0.04^{a}	1.89±0.33^{bc}	2.58±0.31^{c}	0.92±0.18^{ab}
Pb	M.	0.41±0.13^{a}	0.16±0.04^{a}	0.44±0.15^{a}	0.31±0.05^{a}	0.29±0.11^{a}	0.28±0.13^{a}
	L.	1.01±0.16^{a}	0.59±0.12^{a}	1.28±0.44^{a}	1.79±0.35^{a}	0.93±0.19^{a}	1.08±0.38^{a}
Zn	M.	8.78±0.67^{b}	4.34±0.84^{a}	9.24±0.83^{b}	11.2±1.15^{b}	3.41±0.72^{a}	9.79±1.06^{b}
	L.	17.5±1.45^{a}	37.9±2.75^{b}	19.5±1.12^{a}	20.6±1.77^{ab}	16.0±2.58^{a}	32.3±7.15^{ab}

*Horizontally, letters *a*, *b* and *c* show differences among sites. Means with the same letter are not statistically significant, p>0.05 (H.M.: Heavy metal, T.: Tissue, M.: Muscle, L.: Liver, SE: Standard error).

TABLE 2 - Comparison of the overall heavy metal concentrations in the muscles of *Trachurus trachurus* from Turkey waters with other studies from different seas and guidelines.

Sites	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
[a]This study	<0.01-0.08	0.03-0.16	0.07-0.26	0.48-1.30	19.3-52.3	0.19-0.86	0.06-1.03	0.08-0.44	3.41-11.2
[b]Tüzen (2003)	0.09-0.48	-	-	1.28-2.93	9.52-32.4	1.33-3.76	-	0.22-0.74	9.50-22.94
[c]Türkmen et al (2007)	0.02-0.30	0.04-0.26	0.07-1.19	0.34-16.7	18.5-72.3	0.07-2.58	0.01-2.78	0.04-1.31	3.36-42.6
[d]Tepe et al (2008)	0.01-0.40	0.03-0.44	0.10-1.60	0.15-5.06	8.93-160	0.08-1.12	0.02-4.22	0.11-1.00	3.15-12.9
[e]Türkmen et al (2009)	0.01-0.38	0.01-0.53	0.05-1.87	0.21-5.89	11.6-43.3	0.14-1.33	0.06-4.70	0.09-0.81	3.85-15.9
[f]Mendil et al (2010)	0.10-0.62	0.14-0.87	0.38-2.2	0.56-3.1	13.9-107	0.44-8.7	-	0.17-1.1	6.4-52.9
[g]Minganti et al (2010)	<0.01	-	-	1.3-2.2	8.8-19	0.3-0.6	-	-	15-22
[h]da Silva Carneiro et al (2011)	-	-	0.50	0.18	6.12	0.27	0.02	-	6.74
[i]Guideline	0.1	-	-	20	-	-	-	1.0	50
[j]Guideline	0.05-5.5	-	1.0	10-100	-	-	-	0.5-6.0	30-100

[a]This study, *Trachurus trachurus* (μg g^{-1} wet wt).
[b]Tüzen (2003) [6], five fish species from middle Black Sea (μg g^{-1} dry wt).
[c]Türkmen et al. (2007) [15], five fish species from Black, Marmara, Aegean and Mediterranean seas (μg g^{-1} wet wt).
[d]Tepe et al. (2008) [16], two fish species from Black, Marmara, Aegean and Mediterranean seas (μg g^{-1} wet wt).
[e]Türkmen et al. (2009) [12], two fish species from Black, Marmara, Aegean and Mediterranean seas (μg g^{-1} wet wt).
[f]Mendil et al. (2010) [17], four fish species from Black Sea (μg g^{-1} wet wt).
[g]Minganti et al. (2010) [18], İtaly (μg g^{-1} dry wt).
[h]da Silva Carneiro et al. (2011) [14], two fish species from Sepetiba Bay (μg g^{-1} wet wt).
[i]TKB (2002) [21], Turkish Permissible Concentrations.
[j]Nauen (1983) [20], The ranges of maximum permissible concentrations for different countries (FAO) (μg g^{-1} wet wt).

The tissue concentrations of the analyzed heavy metals were significantly affected by sampling sites, and differences between the heavy metal levels in similar tissues of samples from different locations were statistically significant ($p<0.05$). In muscles, the levels of cadmium and manganese in BRT, cobalt, nickel, zinc and iron in NAS, chrome and copper in IB, and lead in YLV were higher than those at other locations. Again in muscles, cadmium in YLV and NAS, and lead in BRT, cobalt and iron in IB, chrome, manganese and nickel in YLV, copper and zinc in CAS had lower levels than those at other locations. In livers, the levels of cadmium, copper, manganese and zinc in BRT, cobalt and iron in CAS, chrome in IB, nickel in SNP and lead in NAS were higher than those in other locations. Again in livers, the levels of cadmium, cobalt, chrome, manganese and nickel in YLV, copper in SNP, iron and lead in BRT, zinc in CAS had lower levels than those in other locations.

Table 2 compiles the data on concentrations of heavy metals in the muscles of *Trachurus trachurus* from coastal waters of Turkey with other studies, Turkish permissible concentrations (TPCs) and tolerable concentrations in fish according to the Turkish Fisheries Law and Regulations. When our results were compared with other studies, as can be seen, the concentrations of Cd, Cu, Mn, Pb and Zn presented by Tüzen [6] were generally higher but that of Fe lower than our results. The concentrations of all heavy metals reported by Türkmen et al. [15] were generally higher than our results. All heavy metal levels reported by Tepe et al. [16], except Mn and Zn, were in agreement with ours, but higher than our results. Although Fe level presented by Türkmen et al. [12] was lower than our results, Mn and Zn levels were higher, whereas others were in agreement. Metal levels presented by Mendil et al. [17] were higher than our results. Although Cd, Fe and Mn levels reported by Minganti et al. [18] were lower, Cu and Zn levels were higher than our results. The levels of all heavy metals, except Cr, presented by da Silva Carneiro et al. [14] were lower than our results. In general, there were differences between the levels of some heavy metals reported in this study and other studies; the reason for these differences may be different species, sampling location and season. It is very difficult to compare the heavy metal concentrations, even within the similar tissues of two different species, because of different feeding habits, the differences in the aquatic environments concerning the source and level of water pollution [19], growing rates of the species, types of tissues analyzed, and some other factors. Thus, the differences between heavy metal accumulations in similar tissues of different species are probable ones. When our results were compared with guidelines, Cd, Cr, Cu, Pb and Zn levels were lower than those in UN FAO Codex for fish and Turkish Fisheries Law and Regulations [20, 21].

The present study provides useful information on the distribution of heavy metal concentrations in tissues of *Trachurus trachurus* from coastal waters of Turkey (Black, Marmara, Aegean and Mediterranean seas). Based on the samples analyzed, the values for cadmium, cobalt, chrome, copper, iron, manganese, nickel, lead and zinc measured in the edible parts of fish are not heavily burdened with heavy metals, and the concentrations did not exceed the established quality standards for fish and mussels [20, 21]. Therefore, it can be concluded that these heavy metals in edible parts of the examined species should pose no health problems for consumers. However, in the future, bioaccumulation of analyzed heavy metals in this study can be a possible risk for the consumption of these species, if the dose of pollution discharged into these seas increases.

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REFERENCES

[1] Lee, YH., Stuebing, R.B. (1990). Heavy metal contamination in the River Toad, *Bufo juxtasper* (Inger), near a copper mine in East Malaysia. B Environ Contam Tox 45: 272-279.

[2] Gümgüm, B., Ünlü, E., Tez, Z., Gülsün, Z. (1994). Heavy metal pollution in water, sediment and fish from the Tigris River in Turkey. Chemosphere 29: 111-116.

[3] Jefferies, DJ., Freestone, P., (1984). Chemical analysis of some coarse fish from a Suffolk River carried out as part of the preparation for the first release of captive-bred otters. J Otter Trust 1: 17-22.

[4] Güven, K., Özbay, C., Ünlü, E., Satar, A. (1999). Acute lethal toxicity and accumulation of copper in *Gammarus pulex* (L.) (Amphipoda). Turk J Biol 23: 510-521

[5] Alam, MGM., Tanaka, A., Allinson, G., Laurenson, LJB., Stagnitti, F., Snow, E. (2002). A comparison of trace element concentrations in cultured and wild carp (*Cyprinus carpio*) of lake Kasumigaura, Japan. Ecotox Environ Safe 53: 348-354.

[6] Tüzen, M. (2003). Determination of heavy metals in fish samples of the middle Black Sea (Turkey) by graphite furnace atomic absorption spectrometry. Food Chem 80: 119-123.

[7] Türkmen, A., Türkmen, M., Tepe, Y., Akyurt, İ. (2005). Heavy metals in three commercially valuable fish species from İskenderun Bay, Northern East Mediterranean Sea, Turkey. Food Chem 91:167-172.

[8] Türkmen, A., Tepe, Y., Türkmen, M. (2008). Metal levels in tissues of the European Anchovy, *Engraulis encrasicolus* L., 1758, and Picarel, *Spicara smaris* L., 1758, from Black, Marmara and Aegean seas. B Environ Contam Tox 80: 521-525.

[9] Bilandžić, N., Đokič, M., Sedak, M. (2011). Metal content determination in four fish species from the Adriatic Sea. Food Chem 124: 1005-1010.

[10] Rayment, GE., Barry, GA. (2000). Indicator tissues for heavy metal monitoring-additional attributes. Mar Pollut Bull 7-12: 353-358.

[11] Mendil, D., Uluözlü, ÖD., Hasdemir, E., Tüzen, M., Sari, H., Suiçmez, M. (2005). Determination of trace metal levels in seven fish species in lakes in Tokat, Turkey. Food Chem 90: 175-179.

[12] Türkmen, A., Tepe, Y., Türkmen, M., Mutlu, E. (2009). Heavy Metal Contaminants in Tissues of the Garfish, *Belone belone* L., 1761, and the Bluefish, *Pomatomus saltatrix* L., 1766, from Turkey Waters. B Environ Contam Tox 82: 70-74.

[13] Türkmen, A., Türkmen, M., Tepe, Y., Çekiç, M. (2010). Metals in tissues of fish from Yelkoma Lagoon, northeastern Mediterranean. Environ Monit Assess 168: 223-230.

[14] da Silva Carneiro, C., Mársico, ET., de Jesus, EFO., de Oliveira Resende Ribeiro, R., de Faria Barbosa, R. (2011). Trace elements in fish and oysters from Sepetiba Bay (Rio de Janeiro-Brazil) determined by total reflection X-ray fluorescence using synchrotron radiation. Chem Ecol 27; 1-8.

[15] Türkmen, M., Türkmen, A., Tepe, Y. (2007). Metal contaminations in five fish species from Black, Marmara, Aegean and Mediterranean seas, Turkey. J Chil Chem Soc 52: 1314-1318.

[16] Tepe, Y., Türkmen, M., Türkmen, A. (2008). Assessment of heavy metals in two commercial fish species of four Turkish seas. Environ Monit Assess 146: 277-284.

[17] Mendil, D., Demirci, Z., Tüzen, M., Soylak, M. (2010). Seasonal investigation of trace element contents in commercially valuable fish species from the Black sea, Turkey. Food Chem Toxicol 48: 865-870.

[18] Minganti, V., Drava, G., De Pellegrini, R., Siccardi, C. (2010). Trace elements in farmed and wild gilthead seabream, *Sparus aurata*. Mar Pollut Bull 60: 2022-2025.

[19] Papagiannis, I., Kagalou, I., Leonardos, J., Petridis, D., Kalfakaou, V. (2004). Copper and zinc in four freshwater fish species from Lake Pamvotis (Greece). Environ Int 30: 357-362.

[20] Nauen, CE. (1983). Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fish Circular. 764, 102 p.

[21] TKB (2002). Fisheries laws and regulations. Ministry of Agriculture and Rural Affairs, Conservation and Control General Management, Ankara.

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CORRESPONDING AUTHOR

Yalcin Tepe
Giresun University
Faculty of Science and Arts
Department of Biology
28049 Giresun
TURKEY

Phone: +905366008390
Fax: +904542161255
e-mail: yalcintepe@hotmail.com