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Assessment of Heavy Metal Levels in Tissues of Common Guitarfish (*Rhinobatosrhinobatos*) from Iskenderun and Antalya Bays, Northeastern Mediterranean Sea

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According to dry weight basis analysis, the lowest heavy metal level was generally detected in the muscle and the highest amount was determined in the intestine in both bays. Although the results of Iskenderun bay were higher than Antalya bay. When the heavy metal levels in the muscle are compared with the national and international standards, it was indicated that the metal concentrations were below the permissible limits. From this aspect, Iskenderun and Antalya bays do not contain adequate amounts of heavy metal to cause pollution.

[**Keywords**:Common guitarfish, *Rhinobatosrhinobatos*, Iskenderun Bay, Antalya Bay, Heavy metal]

Introduction

Heavy metal pollution is an important factor which reduces the quality of water and sediment, and fish health can be negatively affected by this. Because the heavy metals do not undergo decomposition and they lead acute and/or chronic toxic effects on the organisms by accumulating in their metabolisms[44]. Thus, the heavy metal discharging to the aquatic ecosystems can be seriously hazardous on both ecosystems and organisms living in these ecosystems[30]. For instance, Cd causes to change the structure of the gills, to damage to the neural functions, nephrotoxicity, and to inhibit the growth in the fish[52]. As for Hg, it exists as methyl mercury in the fish muscle and leads to effect negatively to the central nervous system and kidneys especially during the development[31]. When the fish exposed to the heavy metals are consumed by human who are in the top of the food chain, human can affect directly or indirectly with this pollution. For example, Itai-Itai disease occurred when humans consumed the fish, rice, and mollusks exposed to Cd pollution from discharges of a mining plant in Fugawa, Japan, in 1955[7].

The heavy metals are commonly defined as more than 5 g/cm^3 density elements[16]. For this reason, they sink themselves and with particles to the sediment[11]. Therefore, it can be expected that the sediment contains more heavy metal amounts than the water column[4,9,17&23]. For this reason, as common guitarfish (*Rhinobatosrhinobatos*) spends most of his time under the sediment, it was selected for the study. Thus, after determining the heavy metal contents in the tissues, the assessment of the possible dimensions of the heavy metal contamination in Iskenderun and Antalya bays was targeted by taking into account national and international standards.

Materials and Methods

The study was conducted in Iskenderun and Antalya bays between March 2007 and October 2007 (Figure 1). Common guitarfish (*Rhinobatosrhinobatos*L., 1758) belonged to Rhinobatidae family from the cartilaginous fishes was preferred as the fish material by hunting operations from the bays. Some reasons such as being common guitarfish a benthic species, spending his most of the time under the sediment by burrowing[12,13&50], and feeding on the pollution representing foods such as mollusks and mussels[51] led common guitarfish to choose and assess the heavy metal pollution in the bays.

21 common guitarfishes from Iskenderun Bay between March 2007 and April 2007 and 20 guitarfishes from Antalya Bay between September 2007 and October 2007 were caught by means of bottom trawling and long-line fishing. Fish samples brought to the laboratory, were weighed and their heights were measured. The mean heights andweights of fish samples of both bays were found 64.6 ± 2.12 cm, 54.5 ± 3.66 cm, 833.0 ± 96.6 g, and 588.0 ± 132.0 g, respectively.

Muscle, liver, gonad, gill, and intestine tissues were removed carefully from each fish sample using sterile dissection tools for the analysis. Removed tissues were labeled by weighing to be the range between 0.5 g and 1 g and dried up in the incubator under 105˚C throughout 48 hours. Dried samples were put in to the conical flask and extracted by adding on them analytical quality of concentrated sulfuric and nitric acids to solve the samples[46]. Extracting of the samples were provided via extraction process. Samples were heated on the flat heater in the flume hood in order to have better and faster solving and clearing. After the extracting of samples, they were cooled, and were filtrated by using 589/3 Ø100 blue-band filter paper. After the process, ionized water was added on the samples up to 25 ml[28]. Thus, the samples were prepared to be analysis. Heavy metal concentrations within the samples were determined by using ICP-AES Variant Liberty Series-2, Mulgrave, Victoria, Australia. Accuracy and controlling of the device in terms of ICP results were assured with Standard Reference Substance (Dorm-2, Shark muscle).

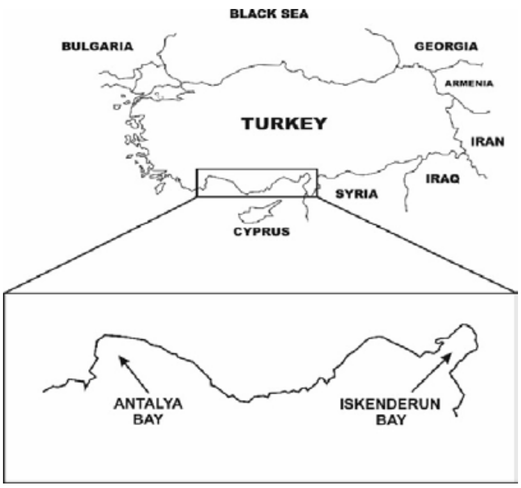

Figure 1-Antalya and Iskenderun bays

While t-test was used to determine the differences of the accumulation of the heavy metals for the bays, One Way ANOVA was used to specify the discrepancies for the tissues. One Way ANOVA Post Hoc Test (Tukey) was applied to determine the statistical importance of the discrepancies. Correlations between the accumulations of the heavy metals were evaluated with Pearson Correlation Coefficient (R). SPSS 13.0 computer software program was used for the all statistical calculations.

Results and Discussion

Heavy metal bioaccumulation

The heavy metal accumulation results in the muscle, liver, gill, gonad, and intestine of the common guitarfish caught from Iskenderun and Antalya bays were presented in the Table 1.

Table 1-The heavy metal contents of common guitarfish in terms of the bays and tissues (mg/kg dry weight)

		Muscle	Liver	Gill	Gonad	Intestine
Cd	İsk.	0.07±0.00**b**	0.20±0.06**bA**	0.13±0.06**b**	0.16±0.06**b**	0.50±0.12**a**
	Ant.	0.06±0.01	0.08±0.01**B**	0.26±0.11	0.30±0.12	0.34±0.11
Co	İsk.	0.09±0.02**b**	0.31±0.03**a**	0.12±0.02**b**	0.10±0.02**b**	0.14±0.03**b**
	Ant.	0.10±0.02	0.17±0.02	0.14±0.02	0.12±0.02	0.13±0.02
Cr	İsk.	0.39±0.05**bA**	0.50±0.10**ab**	0.40±0.07**b**	0.39±0.06**b**	0.75±0.17**a**
	Ant.	0.22±0.04**B**	0.51±0.10	0.31±0.05	0.49±0.14	0.43±0.06
Cu	İsk.	1.54±0.25**bA**	3.81±0.51**b**	1.51±0.09**bA**	1.76±0.17**b**	7.46±0.17**aA**
	Ant.	1.39±0.23**B**	3.14±0.84	1.14±0.09**B**	3.09±0.67	2.63±0.52**B**
Fe	İsk.	50.8±5.75**b**	99.4±4.92**b**	74.4±6.77**bA**	65.0±8.61**b**	221.0±42.7**aA**
	Ant.	41.9±5.10**b**	76.5±10.7**ab**	48.9±6.58**bB**	98.6±17.5**a**	110.0±22.7**aB**
Mn	İsk.	0.68±0.16**b**	1.74±0.22**b**	2.01±0.20**bA**	0.90±0.24**b**	5.20±1.14**a**
	Ant.	0.76±0.18**b**	2.04±0.42**ab**	1.02±0.29**bB**	1.08±0.24**b**	3.25±1.01**a**
Ni	İsk.	0.96±0.12**b**	1.79±0.49**b**	1.44±0.53**b**	1.17±0.26**b**	3.75±1.05**a**
	Ant.	0.56±0.17	0.93±0.17	0.74±0.11	0.98±0.11	1.36±0.53
Pb	İsk.	0.43±0.07	0.72±0.12	0.59±0.10	0.61±0.11	0.68±0.09**A**
	Ant.	0.59±0.10**b**	1.01±0.10**a**	0.93±0.16**ab**	0.68±0.09**ab**	1.06±0.11**aB**
Zn	İsk.	9.94±1.13**b**	16.3±1.92**b**	16.6±2.40**bA**	26.5±4.08**a**	18.2±1.43**bA**
	Ant.	11.3±1.88**b**	15.6±1.85**a**	7.31±0.69**bB**	24.2±3.66**a**	29.9±3.26**aB**

*Different small letters show the importance of average rates on the same line and capital letters do it in the same column.

The lowest Cd amounts (0.06 and 0.07 mg/kg) and the highest (0.34 and 0.50 mg/kg) were found in the muscle and intestine, respectively. Discrepancies between the tissues were, however, determined important only in the Iskenderun Bay. significant results between the bays were derived from the liver samples.

Lowest Co amounts (0.09 and 0.10 mg/kg) and the highest (0.31 and 0.17 mg/kg) were found in the muscle and intestine, respectively. Discrepancies between Co contents were, however, determined important only in the Iskenderun Bay and the discrepancy was derived from the liver samples.

While the lowest Cr values (0.39 and 0.22 mg/kg) were determined in the muscle in both bays, the highest results were came across as 0.75 mg/kg in the intestine in Iskenderun and 0.51 mg/kg in the liver in Antalya. Discrepancies between Co contents were, however, determined important only in the Iskenderun Bay and the discrepancy was derived from the intestine samples. While differences between the tissues obtained samples from Antalya were not important, the significant results between the bays were derived from the muscle samples.

Copper content in the intestine was important only in the sample of Iskenderun. While the lowest Cu ratios (1.14 and 1.51 mg/kg) were determined in the gill in both bays, the highest results were came across as 7.46 mg/kg in the intestine in Iskenderun and 3.14 mg/kg in the liver in Antalya. The difference between the bays was found significant for muscle, gill, and intestine.

The lowest Fe amounts (41.9 and 50.8 mg/kg) and the highest (110.0 and 221.0 mg/kg) were found in the muscle and intestine, respectively. Discrepancies between the tissues were determined important in both Iskenderun and Antalya bays. While mean values of Fe of the gill and intestine samples were significant according to the bays, this was not important for the others.

The lowest Mn amounts (0.68 and 0.76 mg/kg) and the highest (3.25 and 5.20 mg/kg) were found in the muscle and intestine, respectively. Contents of the intestine were caused the differences between the tissues to be important, while the gill samples were led the discrepancies between the bays to be significant.

The lowest Ni amounts (0.56 and 0.96 mg/kg) and the highest (1.36 and 3.75 mg/kg) were found in the muscle and intestine, respectively. Discrepancies between the tissues were, however, determined important only in the Iskenderun Bay. Discrepancy was derived from Ni contents of the intestine.

While the lowest Pb values (0.43 and 0.59 mg/kg) were determined in the muscle in both bays, the highest results were came across as 0.72 mg/kg in the liver in Iskenderun and 1.06 mg/kg in the intestine in Antalya. According to the assessment of the bays, the differences between the contents of the intestine were found important.

The discrepancies between the Zn contents of the tissues were significant for both Iskenderun and Antalya. The contents of Zn of the tissues were significant only in the contents of the gill, and intestine between the bays. While the highest Zn amounts were determined as 26.5 mg/kg in gonad samples in Iskenderun and 29.9 mg/kg in the intestine in Antalya, the lowest results were found as 7.31 mg/kg in the muscle in Iskenderun and 9.94 mg/kg in the gill in Antalya.

Correlations between the heavy metal contents

Correlations between the contents of the heavy metal were examined in the study and important ones of them were given in the Table 2.

Table 2-Important correlations of heavy metal contents among different tissues

Correlations	Pearson Correlation Co-efficiency (R)	Importance (P)
Cd		
Liver &Intestine Content	0.43*	0.016
Cr		
Liver &Intestine Content	0.53**	0.002
Cu		
Liver &Intestine Content	-0.35*	0.047
Muscles &Gill	0.59**	0.000
Muscles &Intestine Content	0.39*	0.044
Gill &Intestine Content	0.41*	0.020
Gonad &Intestine Content	0.74**	0.000
Muscles & Gonad	0.47*	0.016
Mn		
Muscles & Liver	-0.46*	0.017
Muscles &Intestine Content	0.40*	0.043
Ni		
Liver & Gonad	0.38*	0.026
Pb		
Muscles & Liver	-0.45*	0.022
Zn		
Muscles & Liver	0.44*	0.023
Liver &Intestine Content	0.43*	0.016
Gill &Intestine Content	-0.40*	0.026

Correlations signed with "*"are important at 0.05 and the ones signed with "**" are important at 0.01

As can be seen in the table, significant correlations between the content of liver and intestine in point of Cd and Cu; the content of the muscle and gill, muscle and intestine, gill and intestine, gonad and intestine, and muscle and gonad in respect to Cu; the content of the muscle and liver, and muscle and intestine with regard to Mn; the content of the muscle and liver, liver and intestine, and gill and intestine in the way of Zn were determined. Among these correlations, while the content of the liver and intestine in point of Cu, the content of the muscle and liver in point of Mn and Pb, and the content of the gill and intestine in respect to Zn were found negative, the others were determined positive.

When heavy metal concentrations for each tissue were compared with the other studies (Table 3), the Cd and Cu concentrations measured for three ray species by Zauke[53] in the muscle tissue were similar with this study. Nickel and Pb ratios were lower and Zn levels were greater. Asente[2] found higher Cd, Cr, Cu, Mn, and Zn concentrations in the muscle of *Raja kenojei* and *Raja kwangtungensis*, while Co and Pb measurements were lower than the present study. As for *Acipenserruthenus*, Jaric[15] obtained greater Cd and Zn, while Cu and Fe were lower than this study in the muscle tissue. When compared with the present study, Turkmen[41] found similar results in the six ray species except for Cu. Copper levels were lower. Turkmen[42] also obtained similar results except for Fe.

In terms of liver tissue; Zauke[53] ascertained distinct results. The Cd, Cu, and Zn were higher and Ni and Pb were lower than this study. Similarly measurements from two ray species[3] were different from the present study. While Cu concentrations were similar with this study, Ni was higher and Cd, Cr, Pb, and Zn values lower. Jaric[15] found out higher Cd, Cu, Fe, and Zn, while Ni was lower than this study for *Acipenserruthenus*. On the other hand, measurements of Cr, Fe, Ni, Pb, and Zn levels for six ray species were greater and Cu was lower than the present study and Cd and Co results were similar[41]. For seven ray species, Turkmen[42] measured higher Fe, Mn, Ni, and Pb concentrations and lower Zn levels, while Cd, Co, Cr, and Cu were similar.

When the results of gill tissue compared with the other studies, it was determined that all heavy metal concentrations found by Canli and Atli[5] were higher than the present study. Jaric[15] ascertained greater Cu, Fe, and Zn levels, while Cd and Ni ratios were lower than this study. Measurements from the seven shark species[48]were different from the present study. The Cd ratios were higher and Fe and Mn levels lower than this study, while Cu, Ni, and Pb concentrations were similar. On the other hand, Turkmen[41]found out similar results for all heavy metals for six ray species. Turkmen[42] obtained higher Cu and Ni values and lower Cu than the present study, while Co, Cr, Fe, Mn, Ni, Pb, and Zn levels were similar.

As for intestine tissue; it was found out that Cu and Zn levels for *Acipenserruthenus* were higher and Cd and Ni lower than the present study, while Fe ratios were similar[15]. Measurements from the six ray species[41] were similar with this study except for Cd and Co. the Cd and Co levels were greater. Turkmen[42] found higher Co and lower Cd and Cu results than the present study, while Cr, Fe, Mn, Ni, Pb, and Zn concentrations were similar. For four deep-sea shark species, Hornung[14] found out greater Cd, Cu, and Zn and lower Fe and Mn levels.

When gonad tissue results compared with the other studies, Vas[48] found higher Ni and lower Cd and Fe than the present study, while Cu, Mn, and Pb were similar. Measurements from five fish species[21] were lower for Cd and Pb levels than this study. The Cu concentrations were similar. It was determined that all heavy metal levels for four deep-sea shark species were lower than the present study[14]. For *Mustelusmustelus*, Storelli[33] ascertained greater Cu and Ni, while Cd, Cr, Pb, and Zn were lower than this study.

Iron concentration was found the highest in the investigated tissues in the bays. Following Fe, Zn was the second highest element. After these two metals, Cu, Mn, and Co amounts were determined higher than the others. Due to the fact that these five elements are essential for the metabolism[1,6,18,20,43&45], they remain in the tissues to use in metabolic activities. Therefore their roles in the metabolism can be led to obtain higher results than Pb, Ni, Cr, and Cd. On the other hand, Pb, Ni, Cr, and Cd are the non-essential elements and hazardous to the aquatic organism even in trace concentrations. Although they do not need in the metabolic activities, they are generally got into the body by way of diffusion, active transport, and endocytosis[29] and accumulate in the tissues via transporting with blood. Due to their ability passing through the membrane systems, these results could be found. There are many studies[19,27,32,34,3637,38,39&40] conducted in the Mediterranean Region including Iskenderun and Antalya bays and similar results were also obtained in these studies.

In general, some differences in the metal concentrations of some tissues were observed between the bays. All significant results in metal and tissues were higher in the samples obtained from Iskenderun than Antalya. As mentioned previously, the discrepancies between the pollutants of the bays such as the existence of the iron and steel factory andtwo pipe line terminals and very few rivers inputs to Iskenderun Bay, comparison to Iskenderun, the existence of more tourism and agricultural activities,the lack of treatment plant in the marina and many freshwater inputs to Antalya Bay may lead to get higher results in the Iskenderun Bay.

The highest heavy metal amounts among the tissues were determined in the intestine. The digestion system of the fish begins with mouth and swallow. After the nutrients pass through the mouth and swallow, they are transported to the gastrointestinal region and are excreted from the body. Additionally, marine fishes drink considerable amounts of seawater to keep their osmatic pressure in balance[24]. As drunken water passes through the digestion system, it can be thought that the fishes extract the heavy metals directly from seawater. The nutrients taken into the body via diffusion, active transport, and endocytosis by epithelial cells located on the pyloric cecum which increased the absorption surface of the intestine are transmitted to the tissues by means of blood to maintain the metabolicactivities. When epithelial cells expose to the heavy metals, a mucus layer in which the heavy metals are restrained and leads to decrease the absorption of them occurs surface of thecells[24]. Pärt and Lock[25] were expressed that approximately 95% of Cd into the intestine were held on to this mucus layer and also this mucus layer was acted as a protector to decrease the availability of the organic Hg. Keeping the majority of the heavy metal amounts into the mucus layer and the existence of undigested foods in the intestine may lead to obtain high accumulation in the intestine.

The heavy metal amounts in the liver and gonad were remarkably lower than the intestine. One reason may be that keeping the heavy metals into the mucus layer occurred surface of the epithelial cells and thus the very few amounts of the metals were transmitted to both tissues. On the other hand, metal-binding proteins such as metallothionein (MT) which pass the metals through the plasma membrane serve to regulate the intracellular essential metal levels. The main function of MT is to bind the metals. MT hereby detoxifies the metals by binding the free ions and thereby making them less available for interaction with sensitive biomolecules[24]. Because the metals cannot be metabolized themselves and are only excreted from the body. The acting of metal-binding proteins into the metabolism may cause to gain lower results in both liver and gonad.

As a respiratory tissue, the gills take up mainly dissolved oxygen from seawater into the body. Additionally, they play roles in osmoregulation, acid-base regulation, and taking or excreting of some ions and nitrogenous substances[10&24]. The gills are the major target for metal toxicity due to passing the water continuously through this area. Because the water contains lower dissolved oxygen than in air and a fish has to move approximately 20 liters of water across the gills to extract the same amounts of oxygen in comparison with mammals. Mammals can obtain same amounts of oxygen from 1 liter of air[24]. It means that the gills are exposed to large quantities of metals. Surface of the gills is covered primarily by epithelial membranes both consist of rich in phospholipids and including mucus layer[49]. It is probable that obtained low heavy metal concentrations in the gills may have been caused by this mucus layer and metal-binding proteins. As a matter of fact, Cogun and Sahin[8] were stressed in their studies in which they investigated the effect of zeolite on the accumulation of Pb in some tissues including the gills of *Oreochromisniloticus* that there was no death under the some concentrations of Pb and Pb+zeolite and the reason for this was that the metabolism was slowed down by metal-binding proteins in which were rich in cysteine and had low molecular weight such as MT by binding the metals to the glutathione. In other words, the metabolism improves new mechanisms for adapting the conditions. On the other hand, the heavy metal contents of the gills indicate the heavy metal concentrations in that region and the heavy metal contents of the liver show the accumulation of the heavy metals in the fish[26]. Therefore, unlike the accumulation, the heavy metal amounts in the gills may probably present the heavy metal amounts in the bays.

The heavy metal concentrations were found the lowest in the muscle. Muscles are very important tissues in terms of the function; they play active roles in moving of fish, controlling the bloodstream and also providing the movement of the foods by the peristaltic contractions of the muscles[8]. Such these functions of the muscles in the metabolism rather than as a storage may lead to get the lowest results. Storelli and Marcotrigiano32 found similar results and suggested the reason of this that he liver acted as storage rather than the muscle.

Some important correlations between the heavy metals were observed in the study. As mentioned above, some functional differences

Table 3-Comparison of heavy metal concentration ranges in tissues of rays from this study with other studies (mg kg^{-1})

Studies	Metals and Concentrations (mg kg^{-1})								
	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Muscle									
Zauke et al. (1999)	<0.10	-	-	1.8-3.3	-	-	<0.3	<0.3	
Asante et al. (2008)	0.328-0.492	0.055-0.062	0.33-0.67	3.38-6.71		6.34-9.25		0.072-0.085	30.4-40.1
Jaric et al. (2011)	0.085±0.116	-	-	0.976±0.383	12.494±22.867	-	ND	-	25.176±5.636
Turkmen et al. (2013)	0.05±0.01-0.12±0.01	0.05±0.01-0.14±0.02	0.22±0.05-0.88±0.08	0.60±0.08-1.39±0.18	28.5±2.63-58.2±1.99	0.11±0.03-0.69±0.03	0.22±0.05-1.56±0.23	0.41±0.09-0.65±0.17	6.04±1.07-12.5±0.32
Turkmen et al. (2014)	0.03-0.14	0.07-0.22	0.06-0.97	0.15-1.83	22.4-59.4	0.08-0.83	0.08-4.50	0.04-0.76	5.01-11.3
This Study	0.06±0.01-0.07±0.00	0.09±0.02-0.10±0.02	0.22±0.04-0.39±0.05	1.39±0.23-1.54±0.25	41.9±5.10-50.8±5.75	0.68±0.16-0.76±0.18	0.56±0.17-0.96±0.12	0.43±0.07-0.59±0.10	9.94±1.13-11.3±1.88
National Standards (TKB, 2002)	0.1	-	-	20	-	-	-	1.0	50
International Standards (Nauen,1983)	0.05-5.5	-	1.0	10-100	-	-	-	0.5-6.0	30-100
Liver									
Zauke et al. (1999)	<0.10-8.1	-	-	11-51	-	-	<0.10	<0.3	13-58
Barone et al. (2013)	0.02-0.09	-	0.06-0.41	1.19-5.06	-	-	3.33-5.60	0.04-0.09	3.93-6.89
Jaric et al. (2011)	2.826±3.395	-	-	104.019±58.533	380.318±255.559	-	0.034±0.086	-	123.999±46.435
Turkmen et al. (2013)	0.10±0.02-0.25±0.11	0.12±0.01-0.48±0.18	0.44±0.05-1.40±0.07	1.11±0.07-3.66±0.53	71.6±8.95-157±7.59	0.85±0.26-1.70±0.42	0.47±0.04-7.59±0.97	0.64±0.09-1.20±0.17	8.58±0.68-20.8±2.87
Turkmen et al. (2014)	0.04-0.23	0.08-0.28	0.13-1.07	0.33-3.98	44.4-155	0.23-2.73	0.31-5.22	0.55-1.55	5.71-16.9
This Study	0.08±0.01-0.20±0.06	0.17±0.02-0.31±0.03	0.50±0.10-0.51±0.10	3.14±0.84-3.81±0.51	41.9±5.10-50.8±5.75	0.68±0.16-0.76±0.18	0.56±0.17-0.96±0.12	0.43±0.07-0.59±0.10	9.94±1.13-11.3±1.88

Only the heavy metal values found in muscle tissues compared with national and international standards

Table 3-(Continued)

Studies	Metals and Concentrations (mg kg^{-1})								
	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Gill									
Canli and Atli (2003)	1.56±0.21-2.55±0.71	-	3.31±0.71-14.74±6.00	5.02±0.83-14.64±3.64	152.91±62.33-885.49±514.3	-	-	8.95±3.07-16.25±4.52	63.10±9.10-101.85±11.97
Jaric et al. (2011)	0.147±0.127	-	-	2.046±0.384	379±123.094	-	0.479	-	62.392±15.621
Vas (1991)	<0.02-1.10	-	-	0.05-2.17	9.22-21.71	<0.02-1.26	0.27-1.91	<0.02-0.88	ND
Turkmen et al. (2013)	0.07±0.01-0.19±0.05	0.05±0.01-0.18±0.02	0.27±0.04-0.90±0.08	0.96±0.17-2.75±0.23	43.5±1.99-68.8±2.63	0.59±0.18-3.05±0.33	0.32±0.04-3.20±1.10	0.54±0.11-1.38±0.23	8.90±0.47-19.8±4.92
Turkmen et al. (2014)	0.02-0.13	0.09-0.24	0.07-1.07	0.24-7.11	31.1-125	0.13-2.90	0.27-5.42	0.50-1.16	6.43-16.8
This Study	0.13±0.06-0.26±0.11	0.12±0.02-0.14±0.02	0.31±0.05-0.40±0.07	1.14±0.09-1.51±0.09	48.9±6.58-74.4±6.77	1.02±0.29-2.01±0.20	0.74±0.11-1.44±0.53	0.59±0.10-0.93±0.16	7.31±0.69-16.6±2.40
Intestine									
Jaric et al. (2011)	0.335±0.379	-	-	10.556±5.934	148.180±190.126	-	0.714	-	159.755±44.547
Turkmen et al. (2013)	0.10±0.02-3.17±1.44	0.17±0.02-0.27±0.04	0.50±0.07-1.01±0.27	3.25±0.52-8.73±1.56	199±33.6-262±31.8	2.63±0.70-6.75±1.24	2.15±0.50-3.78±0.85	0.67±0.12-0.90±0.18	16.5±2.14-22.7±2.95
Turkmen et al. (2014)	0.04-0.20	0.11-0.26	0.06-0.84	0.64-5.86	39.2-298	0.16-5.69	0.16-3.40	0.37-1.22	9.94-14.1
Hornung et al. (1993)	1.68-5.51	-	-	4.89-49.7	20.0-121.4	1.15-1.70	-	-	27.0-51.1
This Study	0.34±0.11-0.50±0.12	0.13±0.02-0.14±0.03	0.43±0.06-0.75±0.17	2.63±0.52-7.46±0.17	110.0±22.7-221.0±42.7	3.25±1.01-5.20±1.14	1.36±0.53-3.75±1.05	0.68±0.09-1.06±0.11	18.2±1.43-29.9±3.26
Gonad									
Vas (1991)	<0.02-0.06	-	-	0.10-4.88	<0.50-15.05	<0.02-1.96	0.50-8.30	<0.02-0.69	ND
Mormede and Davies (2001)	<0.005-0.034	-	-	<0.50-2.99	-	-	-	<0.005-0.064	-
Hornung et al. (1993)	0.10-0.17	-	-	0.59-1.32	11.9-17.7	ND	-	-	11.3-20.8
Storelli et al. (2011)	0.07	-	0.20	4.39	-	-	2.01	0.15	12.00
This Study	0.16±0.06-0.30±0.12	0.10±0.02-0.12±0.02	0.39±0.06-0.49±0.14	1.76±0.17-3.09±0.67	65.0±8.61-98.6±17.5	0.90±0.24-1.08±0.24	0.98±0.11-1.17±0.26	0.61±0.11-0.68±0.09	24.2±3.66-26.5±4.08

between the tissues such as providing movement and bloodstream by the muscles, taking up the dissolved oxygen and regulating ion exchanges and osmoregulation by the gills, controlling the taking and excreting of the nutrients in the digestion system by the intestine, and some different behavior and movements of the metals such as the existence of epithelial cells in the gills and intestines, on the contrary, containing more metal-binding proteins such as MT of the liver than the other tissues may cause to occur positive or negative important correlations between themetals and tissues.

Conclusion

In the study, between March 2007 and October 2007, 21 common guitarfishes (*Rhinobatosrhinobatos*) from Iskenderun Bay and 20 common guitarfishes from Antalya Bay were caught and the accumulation of the heavy metals in thetissues was investigated. When the heavy metal levels in the muscle are compared with the national and international standards[22&35], it was indicated thatthe metal concentrations were below the permissible limits. Therefore, as a result, it is mentioned that the pollution in the bays was not hazardous on the ecosystems.

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