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The Investigation of Metal and Mineral Levels of Some Marine Species from the Northeastern Mediterranean Sea

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Abstract

In this study, the metal and mineral concentrations of some marine species from Northeastern Mediterranean Sea were determined. Seafood samples were: *Solea solea* (Linnaeus, 1758), *Mullus barbatus* (Linnaeus, 1758), *Upeneus moluccensis* (Bleeker, 1855), *Merluccius merluccius* (Linnaeus, 1758), *Saurida undosquamis* (Richardson, 1848), *Scomber japonicus* (Houttuyn, 1782), *Chelidonichthys lucernus* (Linnaeus, 1758), *Boops boops* (Linnaeus, 1758), *Nemipterus randalli* (Russell, 1986), *Trachurus mediterraneus* (Staindachner, 1868), *Sphyraena pinguis* (Günther, 1874), *Spicara flexuosa* (Rafinesque, 1810), *Lithognathus mormyrus* (Linnaeus, 1758), *Sepia officinalis* (Linnaeus, 1758), *Loligo vulgaris* (Lamarck, 1798), *Melicertus kerathurus* (Forskal, 1775). The differences in Pb, Cu, Zn, Fe, Ca, Mg, and P levels of muscle tissue in all species were determined as 4.26-6.56 µg/g, 0.12-20.62 µg/g, 14.77-119.01 µg/g, 57.90-91.91 µg/g, 728.55-2506.70 µg/g, 1240.70-1758.10 µg/g, and 3539.70-8465.80 µg/g, respectively. The quantity relationships generally found in the metal levels of muscle in all the species were: P>Ca>Mg>Fe>Zn>Cu>Pb.

Keywords

Marine species; Metal accumulation; Northeastern Mediterranean Sea

Introduction

The negative effects of environmental pollution have reached dangerous levels for all organisms on Earth. Metal contamination which is part of this pollution is also one of the most important pollutants for ecosystems. The distribution of metals in nature is held in balance by biological and geological cycles. Mining, industrial and agricultural activities which are performed by human beings from past to present have caused the metal contamination levels in marine ecosystems to increase. Especially metal contamination of marine ecosystems has reached to dramatical levels due to taking it for granted that seas as a system could mask pollution. The negative effects of heavy metal accumulations on ecosystems are increasing day by day. These effects of heavy metal accumulations on ecosystems, compared with other contaminants, cannot be observed in a short period, but it will be able to be observed more in a long term period [1]. Furthermore, metals are also playing a vital role for metabolisms. The metals as Cu, Zn, and Fe can be defined as essential metals. Although these metals are necessary for metabolism in normal concentrations, they may show toxic effects in higher concentrations [2]. Non-essential metals are thought that they do not play any important roles for metabolisms. However, some metals, particularly Hg, Pb ve Cd can be highly toxic even in low concentrations [3].

Although some living species consumed by human beings function as a source of food, they may also extend the effects of pollution more effectively. Therefore, heavy metal levels of species collected from their natural habitat are very important indicators in terms of causing possible risks for human health and heavy metal contamination in their habitat.

Various toxic elements as heavy metals in aquatic ecosystems can be accumulated through the food chain and they can be dangerous for human health when consumed as food [4]. Heavy metals are potentially harmful for marine organisms. In marine food web, metals accumulate increasingly in the direction of top trophic zones. This leads to the increase of metal accumulation in humans when they consume edible fish and invertebrate species.

Heavy metal deposition occurs not only in the internal organs such as liver, kidney and spleen but also in skeletal muscles. Marine species are also rich in minerals such as Ca, Mg, P. Minerals have important tasks in metabolism. Muscle tissues of marine species are consumed more by humans compared to other parts. Knowing heavy metals and mineral levels of muscle is important for human health. Levels of heavy metals and minerals in muscle tissues of marine species have been determined by many researchers [5-10].

There are several factors that affect pollution in the Mersin Bay as well as other marine ecosystems. Artificial fertilizers and pesticides heavily used in agricultural activities, household waste in the region, industrial plants such as chrome, plastic, fertilizer, glass plants and waste from the port have been shown as the main sources of pollution in the Mersin Bay by Kalay et al. (2004) [11]. This study aims to determine the levels of metals and minerals of consumable species caught in the Mersin Bay and also to determine whether these levels are above the limit levels or not.

Materials and Methods

Materials

Marine species were caught by trawl net from Mersin Bay, in December of 2011 on the coast of the Northeastern Mediterranean Sea. Marine samples were: *Solea solea* (Linnaeus, 1758), *Mullus barbatus* (Linnaeus, 1758), *Upeneus moluccensis* (Bleeker, 1855), *Merluccius merluccius* (Linnaeus, 1758), *Saurida undosquamis* (Richardson, 1848), *Scomber japonicus* (Houttuyn, 1782), *Chelidonichthys lucernus* (Linnaeus, 1758), *Boops boops* (Linnaeus, 1758), *Nemipterus randalli* (Russell, 1986), *Trachurus mediterraneus* (Staindachner, 1868), *Sphyraena pinguis* (Günther, 1874), *Spicara flexuosa* (Rafinesque, 1810), *Lithognathus mormyrus* (Linnaeus, 1758), *Sepia officinalis* (Linnaeus, 1758), *Loligo vulgaris* (Lamarck, 1798), *Melicertus kerathurus* (Forskal, 1775). In each species, 10 individuals were caught and kept in polystyrene boxes with ice, and were brought to the laboratory.

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Table 1: The length and weight measurements of some fresh seafood in Mersin Location.

Latino name	Weight (g) $\overline{X} \pm S_{\overline{X}}$	Min-max (g)	Lenght (mm) $\overline{X} \pm S_{\overline{X}}$	Min-max (mm)	Common name
Solea solea (Linnaeus , 1758)[1]	112.33 ± 6.18	105-120	223.00 ± 7.58	210-230	Common sole[1]
Mullus barbatus (Linnaeus, 1758)[2]	42,33 ± 5.92	35-51	156.00 ± 15.16	140-180	Red mullet[2]
Upeneus moluccensis (Bleeker, 1855)[3]	35.33 ± 3.38	32-41	124.10 ± 8.25	110-130	Goldband goatfish[3]
Merluccius merluccius (Linnaeus, 1758)[4]	160.66 ± 7.25	150-171	256.00 ± 11.40	240-270	European hake[4]
Saurida undosquamis (Richardson, 1848)[5]	103.16 ± 8.25	90-115	219.00 ± 6.51	215-230	Brushtooth lizardfish[5]
Scomber japonicus (Houttuyn, 1782)[6]	89.66 ± 5.81	80-96	212.00 ± 10.95	200-230	Chub mackerel[6]
Chelidonichthys lucernus (Linnaeus, 1758)[7]	85.83 ± 8.35	78-100	210.00 ± 12.24	190-220	Tub gurnard[7]
Boops boops (Linnaeus, 1758)[8]	60.00 ± 4.93	56-67	204.00 ± 10.83	190-220	Bogue[8]
Nemipterus randalli (Russell, 1986)[9]	100.33 ± 8.50	91-108	195.00 ± 17.67	170-220	Randall's threadfin bream[9]
Trachurus mediterraneus (Staindachner, 1868)[10]	75.50 ± 4.96	70-80	224.80 ± 8.31	210-230	Mediterranean horse mackerel[10]
Sphyraena pinguis (Günther, 1874)[11]	98.00 ± 5.25	91-104	201.20 ± 7.15	190-210	European baracuda[11]
Spicara flexuosa (Rafinesque, 1810)[12]	151.83 ± 12.13	132-167	190.60 ± 7.09	180-200	Blotched picarel[12]
Lithognathus mormyrus (Linnaeus, 1758)[13]	173.50 ± 9.52	157-180	220.30 ± 7.07	210-230	Striped sea bream[13]
Sepia officinalis (Linnaeus, 1758)[14]	231.83 ± 19.02	210-260	123.00 ± 7.58	110-130	European common cuttlefish[14]
Loligo vulgaris (Lamarck, 1798)[15]	128.16 ± 10.79	111-143	145.00 ± 10.60	130-160	European common squid[15]
Melicertus kerathurus (Forskal, 1775)[16]	83.50 ± 4.96	76-88	198.00 ± 17.88	170-220	Caramote prawn[16]

: mean ± standard error.

Table 2: Metal and mineral content of fish species (μg g^{-1}).

Species	Pb	Cu	Zn	Fe	Ca	Mg	P
	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$
Solea solea [1]	6.56 ± 0.20^{f}	6.68 ± 6.32^{b}	22.84 ± 0.58^{abc}	91.91 ± 3.15^{e}	1916.00 ± 44.90^{g}	1658.90 ± 51.51f^{gh}	4415.20 ± 107.39^{c}
Mullus barbatus[2]	6.34 ± 0.21^{ef}	1.17 ± 0.11^{a}	25.12 ± 0.95^{abc}	69.85 ± 4.06^{bc}	1111.70 ± 68.38^{b}	1341.80 ± 37.70^{ab}	3661.00 ± 100.18^{a}
Upeneus moluccensis[3]	6.20 ± 0.11^{ef}	1.37 ± 0.24^{a}	24.57 ± 1.78^{abc}	83.70 ± 4.68^{de}	2079.90 ± 56.81^{g}	1412.00 ± 9.20^{bc}	3803.70 ± 176.67^{ab}
Merluccius merluccius [4]	6.00 ± 0.05^{de}	0.38 ± 0.09^{a}	19.82 ± 0.75^{abc}	83.97 ± 1.87^{de}	1071.10 ± 73.00^{b}	1625.40 ± 28.99^{efg}	5599.30 ± 149.29^{d}
Saurida undosquamis[5]	5.44 ± 0.17^{bc}	0.34 ± 0.04^{a}	17.59 ± 0.57^{ab}	78.12 ± 3.68^{bcd}	1156.10 ± 42.09^{bc}	1487.90 ± 57.16^{cd}	6774.20 ± 87.42^{f}
Scomber japonicus[6]	5.16 ± 0.15^{b}	1.10 ± 0.06^{a}	26.31 ± 1.92^{abc}	86.12 ± 3.09^{de}	728.55 ± 73.12^{a}	1650.70 ± 55.87^{efgh}	8465.80 ± 336.09^{g}
Chelidonichthys lucernus[7]	5.34 ± 0.20^{b}	0.12 ± 0.01^{a}	28.41 ± 1.37^{bc}	78.95 ± 2.67^{cde}	1566.20 ± 109.91^{ef}	1611.50 ± 44.36^{efg}	5645.00 ± 160.63^{d}
Boops boops[8]	4.37 ± 0.16^{a}	0.29 ± 0.05^{a}	16.11 ± 0.53^{ab}	80.77 ± 5.16^{cde}	1651.70 ± 48.71^{f}	1536.40 ± 16.36^{def}	6486.50 ± 114.03^{ef}
Nemipterus randalli[9]	5.63 ± 0.11^{bcd}	0.24 ± 0.02^{a}	16.81 ± 1.24^{ab}	85.52 ± 1.61^{de}	797.07 ± 86.48^{a}	1758.10 ± 36.39^{h}	6793.20 ± 238.20^{f}
Trachurus mediterraneus[10]	6.38 ± 0.16^{ef}	0.63 ± 0.15^{a}	32.75 ± 2.12^{c}	81.83 ± 2.01^{cde}	2506.70 ± 140.51^{h}	1361.40 ± 39.17^{ab}	6327.20 ± 161.67^{ef}
Sphyraena pinguis[11]	5.88 ± 0.20^{cde}	1.24 ± 0.14^{a}	27.17 ± 2.06^{abc}	80.73 ± 7.42^{cde}	1360.10 ± 48.23^{cde}	1330.40 ± 29.98^{ab}	4286.40 ± 100.47^{bc}
Spicara flexuosa[12]	5.53 ± 0.12^{bcd}	0.30 ± 0.06^{a}	14.77 ± 0.85^{a}	77.47 ± 2.24^{bcd}	733.97 ± 43.37^{a}	1240.70 ± 14.47^{a}	4669.40 ± 171.40^{c}
Lithognathus mormyrus[13]	5.60 ± 0.15^{bcd}	1.09 ± 0.07^{a}	26.91 ± 2.18^{abc}	89.94 ± 8.11^{de}	1389.30 ± 87.95^{de}	1579.90 ± 39.75^{def}	6102.50 ± 137.41^{de}

Different letters (a-h) in the same columns for each metal indicate significant differences ($p<0.05$). $\overline{X} \pm S_{\overline{X}}$: mean ± standard error

Sample preparation

Some measurements, length and weight of all samples were done (Table 1). The measurements of length were done using calipers. After that, the muscle tissues of each species group including 10 individuals were taken out by hand. All assays were conducted on triplicate samples of the each homogenates.

Metal analysis

The metal analyses were made according to Canli and Atli (2003) [12] with some modifications. The muscle samples (0.1 g dry weight each) used for metal analysis were dried at 105°C to reach constant weight and then they were added concentrated nitric acid (4 mL, Merck, Darmstadt, Germany) and perchloric acid (2 mL, Merck) to the samples, and they were put on a hot plate set to 150°C until all tissues were dissolved. Inductively coupled plasma mass spectrometer (ICP-MS, Agilent, 7500ce Model) was used to determine metals. The metal concentrations (Pb, Cu, Fe, Zn, Ca, Mg, and P) in samples were detected as μg metal g^{-1} dry weight. High purity multi standard (Charleston, SC, USA) was used for determination of the metals.

Statistical analysis

Statistical analysis of data was carried out with the SPSS 16.0 Duncan's test was used to evaluate the species effect on metal levels.

Results and Discussion

To assess the presence of metal and mineral concentrations in the muscle of seafood, different fish and crustacean species were used. The differences in Pb, Cu, Zn, Fe, Ca, Mg, and P levels of muscle tissue in all species were determined as 4.26-6.56 μg/g, 0.12-20.62 μg/g, 14.77-119.01 μg/g, 57.90-91.91 μg/g, 728.55-2506.70 μg/g, 1240.70-1758.10 μg/g, and 3539.70-8465.80 μg/g, respectively. The quantity relationships generally found in the metal levels of muscle in all the species were: P>Ca>Mg>Fe>Zn>Cu>Pb (Tables 2 and 3). Ayas and Ozogul (2011) [5] reported Pb, Cu, Zn, and Fe levels in muscle tissues of Atlantic blue crab (*Callinectes sapidus*) as 0.2-0.6 mg Pb kg^{-1}, 9.7-68.1 mg Cu kg^{-1}, 39.5-175.2 mg Zn kg^{-1}, and 8.8-32.5 mg Fe kg^{-1}, respectively in Mersin Bay, Northeastern Mediterranean Sea. All our metal levels were similar to those found in that study. This may be related to the fact that the all different species were caught in the same region in both of the studies.

Table 3: Metal and mineral content of crustacean species (μg g^{-1}).

Species	Pb	Cu	Zn	Fe	Ca	Mg	P
	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$	$\overline{X} \pm S_{\overline{X}}$
Sepia officinalis[14]	5.51 ± 0.20b^{cd}	20.62 ± 2.16^{c}	119.01 ± 14.75^{e}	82.43 ± 1.29^{cde}	1644.10 ± 41.43^{f}	1720.00 ± 55.64^{gh}	3539.70 ± 55.82^{a}
Loligo vulgaris[15]	4.32 ± 0.16^{a}	3.99 ± 0.25^{ab}	55.68 ± 0.58^{d}	66.11 ± 2.31^{ab}	1340.70 ± 48.65^{cd}	1650.00 ± 45.25^{efgh}	3822.50 ± 272.50^{ab}
Melicertus kerathurus[16]	4.26 ± 0.16^{a}	7.12 ± 0.44^{b}	60.42 ± 1.41^{d}	57.90 ± 1.64^{a}	1672.40 ± 45.55^{f}	1527.00 ± 20.50^{cde}	5734.80 ± 129.97^{d}

Different letters (a-h) in the same columns for each metal indicate significant differences ($p<0.05$). $\overline{X} \pm S_{\overline{X}}$: mean ± standard error.

In a similar study, Abdallah (2010) [13] reported that Pb, Cu, and Zn levels of some commercially valuable fish species were 0.01-6.49 mg/kg, 0.01-9.69 mg/kg, and 3.90-57.20 mg/kg, respectively, in El-Mex Bay and Eastern harbour, in Egypt. Pb, Cu, and Zn levels presented by those researchers were higher than the data obtained in our study, possible because of the availability of more industrial facilitates in El-mex Bay and Eastern harbour than in Mersin Bay. In a similar study, Canli and Atli (2003) [12] reported Pb, Zn, Fe, and Cu levels in muscle tissue of six Mediterranean fish species as 4.27-6.12 mg/kg, 16.48-37.39 mg/kg, 19.60-78.40 mg/kg and 2.19-4.41 mg/kg, respectively, in Karataş, Northeastern Mediterranean Sea. It can be seen that the results presented by them were similar to those in our study, which may be due to the fact that the Mediterranean fish species had been caught in areas with similar contamination levels. Furthermore; Turkmen et al. (2011) [14] determined metal amounts of *L. labrax, M. cephalus, S. aurata, D. labrax* species as Fe 23.4-51.4 mg/kg , Zn 6.63-14.8 mg/kg , Cu 0.58-0.74 mg/kg , Pb 0.32-1.02 mg/kg, in a study done in Paradeniz Lagoon, in Mersin Bay. Pb, Zn and Fe levels determined by this study were observed to have lower levels than the data obtained in our study. The main reason of this difference can be related to the species captured from the lagoon ecosystem in that study.

Firat et al. (2008) [3] determined metal concentrations in *Charybdis longicollis* as 77.55 g Cu/kg>32.77 g Fe/kg>32.53 g Zn/kg, and in *Penaeus semisulcatus* as 34.24 g Cu/kg>27.75 g Zn/kg>18.69 g Fe/kg in Iskenderun Bay. Metal levels of invertebrate species reported by the researchers had higher levels than the data obtained in our study. The variances in the results of these two studies may have occurred due to the higher levels of metal contamination of the Gulf of Iskenderun compared to Mersin Bay. Tepe et al. (2008) [15] determined Fe, Zn, Pb and Cu levels in *Mullus barbatus* tissues captured in Mersin Bay as 11.5 g/kg, 5.09 g/kg, 0.89 g/kg, and 0.21 g/kg, respectively. It is observed that Zn, Fe, Pb levels were lower than the findings of our study. These differences are thought to result from seasonal, sexual and the size differences of individuals. Turan et al. (2009) [16] found Fe levels in *Mullus barbatus* in the Gulf of İskenderun as high as our findings in our study. High levels of metals such as Zn, Pb, Cu, and Fe in both Bays show the negative effects of industrial activities on the backwaters.

Tables 2 and 3 show trace element levels (Cu, Zn, and Fe) of different fish and crustacean species. Common sole (for fish species) and European common cuttlefish (for crustacean species) were found to be the best sources of Cu among the tested seafood. All crustacean species and tub gurnard and Mediterranean horse mackerel (for fish species) were found to be the best sources of Zn among the tested seafood. Common sole and striped sea bream (for fish species) and European common cuttlefish (for crustacean species) were found to be the best sources of Fe among the tested seafood. The levels of Cu in all fish samples were between 6.68 μg/g for common sole and 0.12 μg/g for tub gurnard whereas its levels for all crustacean species ranged from 20.62 μg/g for European common cuttlefish to 3.99 μg/g for European common squid. The levels of Zn in all fish samples were from 32.75 μg/g for Mediterranean horse mackerel to 14.77 μg/g for blotched picarel although Zn levels for all crustacean species ranged from 119.01 μg/g for European common cuttlefish to 55.68 μg/g for European common squid. The levels of Fe in all fish samples changed between 91.91 μg/g for common sole and 69.85 μg/g for red mullet whereas its level for all crustacean species ranged from 82.43 μg/g for European common cuttlefish to 57.90 μg/g for caramote prawn. The distribution of Cu, Zn, and Fe between the European common squid and caramote prawn was similar whereas European common cuttlefish contained higher amount of Cu, Zn, and Fe than the two crustacean species.

Tables 2 and 3 show Pb levels of seafood. Common sole (for fish species) and European common cuttlefish (for crustacean species) were found to have the levels of Pb in the tested seafood. The levels of Pb in all fish samples changed from 6.56 μg/g for common sole to 4.37 μg/g for bogue whereas its level for all crustacean species ranged from 5.51 μg/g for European common cuttlefish to 4.26 μg/g for caramote prawn. The distribution of Pb between all the fish species (except for bogue) was similar. The distribution of Pb between the European common squid and caramote prawn was similar whereas European common cuttlefish contained higher amount of Pb than the two crustacean species.

Pb levels in muscle tissue of seafood were determined as 4.26-6.56 μg/g (Tables 2 and 3). European Union Commission Regulation (466/2001) [17] and Turkish Food Codex, (2005) [18] set a Pb limit level for fish species at 0.4 μg Pb g^{-1}, for crustacean species at 1 μg Pb g^{-1}. Thus, it can be stated that seafood was contaminated with Pb. Ersoy and Celik (2010) [19] found the maximum Pb concentrations in the muscle and liver of fish species as 0.58 and 0.89 mg/kg (wt/wt) in their study carried out on common sole, gold band goatfish and four different commercial demersal species in the autumn. The results of their study support the results of our study. The value of Pb was determined above the acceptable limit on Mersin Bay.

Cu and Zn levels in muscle tissues of seafood were determined to be 0.12-20.62 μg/g, 14.77-119.01 μg/g, respectively (Tables 2 and 3). The Cu and Zn limit levels reported by Turkish Food Codex (2005) [17], for seafood was 20 μg Cu g^{-1} and 50 mg Zn kg, respectively. Cu levels in all seafood were lower than the reported limit level by Turkish Food Codex (2005) [17], except for Cu levels in European common cuttlefish. Thus, it can be stated that European common cuttlefish were contaminated with Cu. Zn levels in all fish species were lower than the reported limit level by Turkish Food Codex (2005) [17], whereas all crustacean species were higher than the reported limit level by Turkish Food Codex (2005) [17]. Thus, it can be stated that all crustacean species were contaminated with Zn.

Tables 2 and 3 shows macro element levels (Ca, Mg, and P) of different fish and crustacean species. In this study, seafood contained considerable amounts of Ca, Mg, and P. Mediterranean horse mackerel, common sole, and goldband goatfish were found to be the best sources of Ca among the tested seafood. Öksuz et al. (2011) [20]

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reported mineral levels in gold band goatfish as 617.4 mg Ca kg^{-1} and 1754.9 mg P kg^{-1} in their study in the Gulf of Iskenderun. Gold band goatfish levels reported by researchers are as high as the levels in our study. Randall's threadfin bream and European common cuttlefish were found to be the best sources of Mg among the tested seafood. Chub mackerel were found to be the best sources of P among the tested seafood. The levels of Ca in all fish samples were from 728.55 µg/g for chub mackerel to 2506.70 µg/g for Mediterranean horse mackerel whereas its level for all crustacean species ranged from 1340.70 µg/g for European common squid to 1672.40 µg/g for caramote prawn. Ersoy and Celik (2010) [19] found the value of Ca in the range of 72.7-496 mg/kg, in their study with the commercial demersal species. This range was found lower than the value of our study. The levels of Mg in all fish samples were from 1240.70 µg/g for blotched picarel to 1758.10 µg/g for Randall's threadfin bream whereas its level for all crustacean species ranged from 1527.00 µg/g for caramote prawn to 1720.00 µg/g for European common cuttlefish. The levels of P in all fish samples changed from 3661.00 µg/g for red mullet to 8465.80 µg/g for chub mackerel; on the other hand, its level for all crustacean species ranged from 3539.70 µg/g for European common cuttlefish to 5734.80 µg/g for caramote prawn. Common sole, goldband goatfish, tub gurnard, bogue, Mediterranean horse mackerel, European common cuttlefish, and caramote prawn had high Ca content (>1500 µg/g). Common sole, European hake, chub mackerel, tub gurnard, Randall's threadfin bream, European common cuttlefish, and European common squid had high Mg content (>1600 µg/g). Brushtooth lizardfish, chub mackerel, bogue, Randall's threadfin bream, Mediterranean horse mackerel, and striped sea bream had high P content (>6000 µg/g). The distribution of Ca, Mg, and P between the European common cuttlefish, and European common squid was similar whereas caramote prawn contained the higher amount of P than the two crustacean species. Levels of macro elements such as Ca, Mg, P were determined so rich for 16 species examined in Mersin Bay.

Conclusion

Many of the inorganic chemicals are essential for life at low concentration but become toxic at high concentration. While minerals such as copper, calcium, magnesium, phosphorus, iron, and zinc are essential micronutrients for fish and shellfish, other elements such as mercury, cadmium and lead show no known essential function in life and are toxic even at low concentrations when ingested over a long period. IARC classified lead as a 'possible human carcinogen' based on sufficient animal data and insufficient human data in 1987. Metal level analysis of 16 different species in Mersin Bay stated that the levels of Pb were found above the level of the upper limits set by international standards. Being effective in occurrence of high levels of Pb in the aquatic environment is thought as a result of Marine and industrial activities in Mersin Bay. Owing to their toxicity and their possible bioaccumulation, It is thought to be necessary to make a regular analysis to observe the high level of Pb and the possible effects on the ecosystem in the Mersin Bay. Also, exposure measurements are essential for the protection of high risk populations and subgroups.

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