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Research Article

# Comparison of Heavy Metal Levels of Grey Mullet (*Mugil cephalus* L.) and Sea Bream (*Sparus aurata* L.) Caught in İskenderun Bay (Turkey)

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**Abstract:** In this study Fe, Cu, Ni, Cr, Pb and Zn contents were determined in muscle, skin and gonads of two fish species (*Mugil cephalus* L. and *Sparus aurata* L.) caught at three stations in the İskenderun Bay of the Eastern Mediterranean coast of Turkey. Heavy metal concentrations varied significantly depending on the type of the tissue, fish species, and location of stations. Generally, *M. cephalus* showed higher levels of metal concentrations than *S. aurata* in two of the stations in the inner bay; which might have resulted from the difference in foraging habits of the two species. Cu, Zn, Fe, Pb, Ni and Cr concentrations were found to be the highest in *M. cephalus* with 1.39, 47.25, 66.38, 10.02, 1.34 and 1.71 µg $g^{-1}$ w. wt. in muscle, and 44.50, 269.06, 332.56, 90.97, 9.17 and 8.68 µg $g^{-1}$ w. wt. in gonads, respectively. The least amount of contamination was found to be at the station in the opening of the bay. This station does not receive significant levels of effluents from the industrial and domestic sources in İskenderun city when compared to the other two stations.

Key Words: Heavy metals accumulation, İskenderun Bay, *Mugil cephalus*, *Sparus aurata*.

## İskenderun Körfezi'nden Avlanan Has Kefal (*Mugil cephalus* L.) ve Çipura (*Sparus aurata* L.)'da Ağır Metal Düzeylerinin Karşılaştırılması

**Özet:** Bu çalışmada; Türkiye'nin Doğu Akdeniz kıyısında yer alan, İskenderun Körfezi'nde üç istasyonda avlanan has kefal (*Mugil cephalus*) ve çipura'nın (*Sparus aurata*) üreme organları, deri ve kas dokularında Fe, Cu, Ni, Cr, Pb ve Zn düzeyleri belirlenmiştir. Ağır metal düzeylerinin, istasyonlara, balık türlerine ve doku tiplerine göre değişim gösterdiği saptanmıştır. Genelde has kefal'deki (*M. cephalus*) metal birikimlerinin çipura'dan (*Sparus aurata*) daha yüksek olduğu ve bu durumun türlerin beslenme alışkanlıklarının farklılığından kaynaklanabileceği söylenebilir. Has kefal'in kasında en yüksek Cu, Zn, Fe, Pb, Ni ve Cr düzeyleri sırasıyla 1,39, 47,25, 66,38, 10,02, 1,34 ve 1,71 µg/g yaş ağırlık ve gonadında 44,50, 269,06, 332,56, 90,97, 9,17 ve 8,68 µg/g yaş ağırlık olarak bulunmuştur. Körfez içindeki diğer iki istasyonla karşılaştırıldığında, Iskenderun'un evsel ve endüstriyel atıklarının en az etkisinde kalan körfez ağzındaki istasyonun, körfezin en az kirlenmiş bölgesi olduğu belirlenmiştir.

Anahtar Sözcükler: Ağır metal birikimi, İskenderun Körfezi, *Mugil cephalus*, *Sparus aurata*

## Introduction

Heavy metals are natural trace components of the aquatic environment, but their levels have increased due to industrial, agricultural and mining activities. As a result, aquatic animals are exposed to elevated levels of heavy metals (1,2). Some heavy metals such as zinc, copper and cobalt are essential in trace amounts for normal growth and development; however, others such as mercury, cadmium and lead have no biological importance (1-5). All heavy metals are potentially harmful to most organisms at some level of exposure and absorption (4). The levels of metals in upper members of the food web like fish can reach values many times higher than those found in aquatic environment or in sediments (2,6). The studies carried out with different fish species have revealed that both essential and non-essential metals can produce toxic effects in fish by disturbing physiological activities, biochemical processes, reproduction and growth and mortality (4,5,7,8).

In recent years, heavy metal accumulation in fish and other organisms has been investigated along the coast of Turkey (9-16).

İskenderun Bay is situated on the Eastern Mediterranean coast of Turkey (36° 20´ N - 35° 30´ E; 36° 50´ N-35° 00´ E). There are numerous plants, such as Iron and Steel Works (Isdemir), Oil Pipeline Installation (Botaş) and some other small factories. The city also contains a big harbour. Moreover, due to heavy agricultural and industrial activities in the region, the bay receives large quantities of untreated industrial and domestic sewage. Therefore, it is one of the most polluted coastal waters of Turkey. Meanwhile, the Bay has an economical importance for fishery. Thus, contamination in the region is an important issue regarding the health of the aquatic animals and in turn, health of the seafood consumers.

This study was undertaken to investigate the current heavy metal contamination on two commercially important fish species (*S. aurata* and *M. cephalus*) at three stations differing in locations. These two species differ from each other with respect to their habitat and feeding habits. *S. aurata* is a carnivore, the diets of *S. aurata* consists of wide variety of food organism, preferentially selecting gastropods and bivalves (17). The habitat of *M. cephalus*, which is an omnivore, is pelagic, usually inshore, entering estuaries and lagoons. While juveniles feed on invertebrates, adults mostly on detritus, bottom algae and small organisms, occasionally on plankton (18).

## Materials and Methods

Grey mullet (*Mugil cephalus*, Linnaeus 1758) and sea bream (*Sparus aurata*, Linnaeus 1758) were caught by gill net and trawl, respectively, from the three stations shown in the Figure. The first station (A) was chosen in south region of the bay, far from any industrial activities. The second (B) was in the area where Isdemir is located in addition to a large number of other heavy industrial plants. Moreover, the wastewaters of the city are

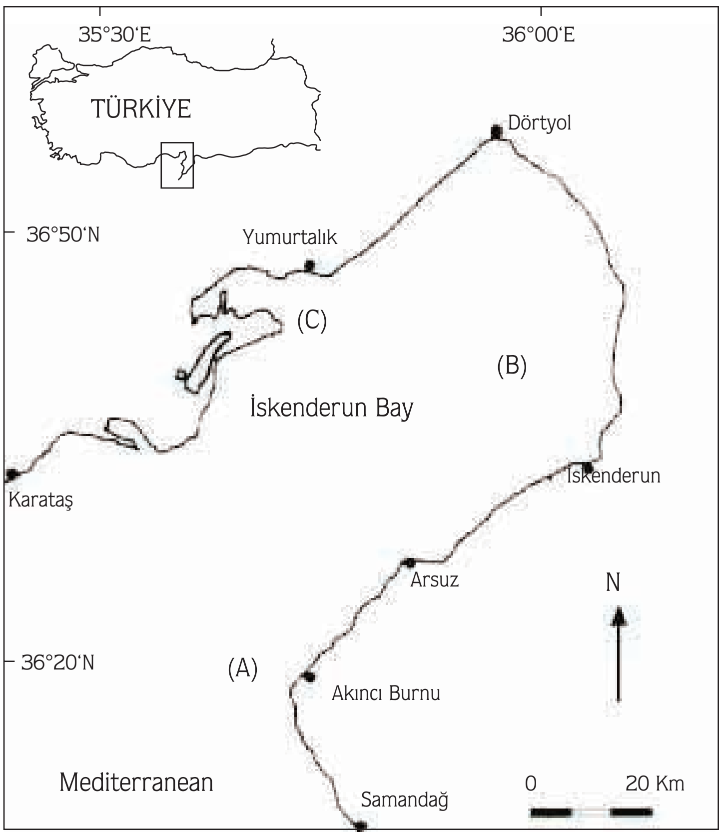


Figure. The map of sampling locations in İskenderun Bay, Turkey.

dumped into the same area. The last one (C) was in the region where Botaş and a number of small industrial plants are located. Fifteen fishes selected from each species were caught in each station in autumn of 1999. The physico-chemical parameters of seawater on that days were determined by a YSI model RS 232.

The samples were brought to the laboratory at the same day, weighed, measured and dissected. For analysis, whole gonads, a piece of skin with scale and epaxial muscle on the dorsal surface of each fish were dissected, weighed and dried at 105 °C until they reached to a constant weight. All samples were placed in decomposition beakers and pure sulphuric acid and nitric acid-hydrogen peroxide (1:1) v/v according to FAO methods were added to each. They were evaporated to dry on a hot plate. The residues were then dissolved and diluted to 50 ml with 2.5% of nitric acid. The chemicals used for sample dissolution were analytical grade. Inductively Coupled Plasma- Atomic Emission Spectrometry (ICP-AES), (Varian Model- Liberty Series II), was used for determination of iron, copper, nickel, chromium, lead and zinc. The following absorption lines were used; chromium 283.6 nm, iron 259.9 nm, copper 324.7 nm, nickel 232.0 nm, lead 283.3 nm, zinc 213.9 nm. Metal concentrations were calculated in microgram per gram wet weight (µg $g^{-1}$ w.wt.). In order to check the validity of measurements, reference material (Multi-4, Merck) was used. Data analyses were carried out using the SPSS statistical package. One way ANOVA and Duncan's Multiple Comparison Test were used to compare the data among stations at the level of 0.05.

## Results

The average size and weight values of each fish sample measured are given in Table 1. The levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) measured in *M. cephalus* and *S. aurata* tissues (muscle, skin and gonads) from three stations are presented in Tables 2 and 3, respectively. Comparisons of the data for three stations, related with the heavy metal levels of tissues, are also given in these tables. The physico-chemical parameters of seawater on that days were 39.02‰ salinity, 27 ± 1.3 °C, 6.92 ± 0.7 mg$l^{-1}$ dissolved oxygen and 7.98 ± 0.6 pH.

Iron concentrations in the muscle tissue of *M. cephalus* ranged from 48.31 to 66.38 µg $g^{-1}$ w. wt., while concentrations in gonads were in the range of 247.71-332.56 µg $g^{-1}$ w. wt. (Table 2). Iron concentrations did not vary significantly ($P > 0.05$) in tissues except in the gonads of the *M. cephalus* in station B. Concentrations of copper in the muscle tissue, skin and gonads of grey mullet ranged from 0.24 to 1.39 µg $g^{-1}$ w. wt., 1.99 to 5.92 µg $g^{-1}$ w. wt., and from 13.01 to 44.50 µg $g^{-1}$ w. wt., respectively. The highest copper concentrations were found at station B. Nickel concentrations varied significantly among stations in the studied tissues of all grey mullet samples (Table 2), ($P < 0.05$). Higher concentrations of nickel were observed in the gonads and lower concentrations were noted in the muscle of grey mullet. Chromium concentrations in the muscle tissue of *M. cephalus* ranged from 1.14 to 1.71 µg $g^{-1}$ w. wt., while concentrations in gonads were in the range of 5.33-8.68 µg $g^{-1}$ w. wt. (Table 2). The level of

Table 1. The stations, number of fishes, female/male, average wet weights and total lengths of fish were measured[a].

| Species | Stations | N | ♀/♂ | L ± S.D | W ± S.D |
|---|---|---|---|---|---|
| | A | 15 | 9/6 | 22.80 ± 1.75 | 74.00 ± 3.17 |
| *Mugil cephalus* | B | 15 | 7/8 | 17.90 ± 0.42 | 67.20± 3.70 |
| | C | 15 | 5/10 | 20.70 ± 1.40 | 69.20 ± 6.06 |
| | A | 15 | 15/0 | 21.90 ± 0.22 | 147.60 ± 13.92 |
| *Sparus aurata* | B | 15 | 15/0 | 21.70 ± 0.45 | 145.80 ± 5.59 |
| | C | 15 | 15/0 | 22.80 ± 1.04 | 151.80 ± 8.45 |

[a] W- mean body weight (g); S.D.- standard deviation; L- mean total length (cm); N- number of fish;
♀/♂ - female/male.

Table 2. The mean heavy metals concentrations (μg $g^{-1}$ wet weight) in muscles, skin and gonads of *M. cephalus* from İskenderun Bay.

| | Stations | Fe | Cu | Ni | Cr | Pb | Zn |
|---|---|---|---|---|---|---|---|
| Muscle | A | 50.70 ± 18.79$^{a*}$ | 0.24 ± 0.22$^{a}$ | 0.73 ± 0.43$^{a}$ | 1.14 ± 0.63$^{a}$ | 3.59 ± 1.79$^{a}$ | 21.62 ± 10.63$^{a}$ |
| | B | 66.38 ± 16.77$^{a}$ | 1.39 ± 0.80$^{b}$ | 1.34 ± 0.58$^{b}$ | 1.71 ± 0.92$^{a}$ | 6.42 ± 2.82$^{b}$ | 47.25 ± 18.77$^{b}$ |
| | C | 48.31 ± 20.91$^{a}$ | 0.99 ± 0.58$^{b}$ | 0.94 ± 0.42$^{ab}$ | 1.42 ± 0.70$^{a}$ | 10.02 ± 2.86$^{c}$ | 30.44 ± 14.68$^{a}$ |
| Skin | A | 88.79 ± 15.97$^{a}$ | 1.99 ± 0.88$^{a}$ | 1.21 ± 0.79$^{a}$ | 1.96 ± 0.78$^{a}$ | 15.86 ± 5.75$^{a}$ | 60.82 ± 17.86$^{a}$ |
| | B | 107.83 ± 35.64$^{a}$ | 5.92 ± 1.21$^{c}$ | 4.33 ± 1.27$^{c}$ | 3.48 ± 1.43$^{b}$ | 39.04 ± 12.94$^{b}$ | 103.74 ± 28.92$^{b}$ |
| | C | 93.14 ± 24.22$^{a}$ | 3.80 ± 1.47$^{b}$ | 2.41 ± 1.02$^{b}$ | 2.65 ± 0.99$^{ab}$ | 50.74 ± 21.17$^{b}$ | 82.64 ± 22.45$^{b}$ |
| Gonads | A | 247.71 ± 39.87$^{a}$ | 13.01 ± 3.68$^{a}$ | 3.35 ± 2.32$^{a}$ | 5.33 ± 2.46$^{a}$ | 30.93 ± 14.23$^{a}$ | 170.08 ± 42.76$^{a}$ |
| | B | 332.56 ± 35.91$^{b}$ | 44.50 ± 10.13$^{b}$ | 9.17 ± 2.42$^{c}$ | 8.68 ± 2.37$^{b}$ | 61.00 ± 14.85$^{b}$ | 269.06 ± 55.77$^{b}$ |
| | C | 256.26 ± 53.93$^{a}$ | 18.84 ± 3.49$^{a}$ | 5.56 ± 1.68$^{b}$ | 6.24 ± 1.96$^{a}$ | 90.97 ± 16.72$^{c}$ | 266.15 ± 71.36$^{b}$ |

*Data show with different letters are statistically significant in columns ($P < 0.05$)

Table 3. The mean heavy metals concentrations (μg $g^{-1}$ wet weight) in muscles, skin and gonads of *S. aurata* from İskenderun Bay.

| | Stations | Fe | Cu | Ni | Cr | Pb | Zn |
|---|---|---|---|---|---|---|---|
| Muscle | A | 20.65 ± 7.78$^{a*}$ | N.D** | 0.29 ± 0.23$^{a}$ | 0.86 ± 0.38$^{a}$ | 4.84 ± 1.67$^{a}$ | 19.31 ± 4.58$^{a}$ |
| | B | 28.81 ± 9.90$^{b}$ | 0.51 ± 0.34$^{a}$ | 0.86 ± 0.37$^{b}$ | 0.99 ± 0.69$^{a}$ | 7.33 ± 1.85$^{b}$ | 31.23 ± 10.21$^{b}$ |
| | C | 24.61 ± 6.72$^{ab}$ | 0.32 ± 0.18$^{a}$ | 0.87 ± 0.20$^{ab}$ | 1.08 ± 0.37$^{a}$ | 6.39 ± 2.49$^{ab}$ | 22.39 ± 6.19$^{a}$ |
| Skin | A | 41.86 ± 24.06$^{a}$ | 0.68 ± 0.46$^{a}$ | 0.85 ± 0.44$^{a}$ | 0.93 ± 0.33$^{a}$ | 11.11 ± 4.25$^{a}$ | 32.01 ± 10.98$^{a}$ |
| | B | 65.05 ± 19.02$^{b}$ | 4.21 ± 2.05$^{b}$ | 5.21 ± 2.42$^{b}$ | 2.96 ± 1.86$^{b}$ | 22.13 ± 8.54$^{b}$ | 54.65 ± 22.65$^{b}$ |
| | C | 51.61 ± 16.65$^{ab}$ | 3.51 ± 1.58$^{b}$ | 1.49 ± 0.58$^{a}$ | 1.67 ± 1.04$^{a}$ | 35.75 ± 11.51$^{c}$ | 36.06 ± 11.66$^{a}$ |
| Gonads | A | 162.93 ± 42.62$^{a}$ | 5.06 ± 2.81$^{a}$ | 0.57 ± 0.51$^{a}$ | 2.87 ± 1.46$^{a}$ | 6.40 ± 2.76$^{a}$ | 66.56 ± 20.01$^{a}$ |
| | B | 198.99 ± 63.96$^{a}$ | 19.02 ± 4.33$^{c}$ | 1.24 ± 0.53$^{b}$ | 4.26 ± 1.87$^{a}$ | 45.28 ± 16.20$^{b}$ | 155.66 ± 72.92$^{b}$ |
| | C | 179.04 ± 54.54$^{a}$ | 9.99 ± 3.28$^{b}$ | 0.47 ± 0.29$^{a}$ | 3.62 ± 1.28$^{a}$ | 75.31 ± 19.20$^{c}$ | 85.33 ± 24.21$^{a}$ |

*Data shown with different letters are statistically significant at the $P < 0.05$ level.
N.D**= Not detected

chromium concentrations in the muscle of grey mullet did not vary significantly (Table 2), ($P > 0.05$). Concentrations of lead in muscle tissue and gonads of grey mullet were observed to be between 3.59 and 10.02 μg $g^{-1}$ w. wt., and between 30.93 and 90.97 μg $g^{-1}$ w. wt., respectively. Lead concentrations varied from station to station ($P < 0.05$), except for the case of skin of grey mullet in stations B and C. Concentrations of zinc in the gonads, skin and muscle tissues of grey mullet ranged between 170.08 and 269.06, 60.82 and 103.74, and 21.62 and 47.25 μg $g^{-1}$ w. wt., respectively.

Iron concentration was between 20.65 and 28.81 in muscles of *S. aurata* μg $g^{-1}$ w. wt. (Table 3). Iron concentrations in the gonads of sea bream did not vary significantly ($P > 0.05$). Copper was not detected in the muscle of sea bream in the station A (Table 3). Copper concentrations in the skin of sea bream ranged from 0.68 to 4.21 μg $g^{-1}$ w. wt., while concentrations in gonads were in the range of 5.06-19.02 μg $g^{-1}$ w. wt. (Table 3). Gonads of sea bream at station B showed significantly higher levels of copper than at station A. Concentrations of nickel in the gonads, skin and muscle tissues of sea bream ranged between 0.47 and 1.24, 0.85 and 5.21, and 0.29 and 0.87 μg $g^{-1}$ w. wt., respectively. Chromium concentrations in the muscle tissue of sea bream ranged from 0.86 to 1.08 μg $g^{-1}$ w. wt., while concentrations in gonads were in the range of 2.87 to 4.26 μg $g^{-1}$ w. wt. (Table 3). Chromium concentrations in the gonads and muscles of sea bream did not vary significantly ($P > 0.05$). Variations in lead concentrations occurred in the skin and gonads of sea bream (Table 3), ($P < 0.05$). While significant differences of lead levels in the muscle were found between the samples at stations A and B, there were no statistical differences between the data at station C and stations A or B. Zinc levels in the muscle tissue and gonads of sea bream ranged from 19.31 to 31.23 µg $g^{-1}$ w. wt. and 66.56 to 155.66 µg $g^{-1}$ w. wt., respectively (Table 3). The highest zinc levels were measured for station B.

## Discussion

In the literature, the amount of bioaccumulations of heavy metals in tissues may vary depending on length and weight of samples (19,20). Therefore, the samples were chosen to be around the same weight and length for each station in this study. Kargın (14) stated that due to variations in feeding habits, habitats and behaviour of species, the levels of metals found in tissues of the benthic *Mullus barbatus* were always higher than those found in pelagic *S. aurata* throughout the year. Romeo et al. (21) pointed out that cadmium, copper, mercury and zinc concentrations in edible muscles of pelagic fish species are lower than for benthic fish species. Although *M. cephalus* and *T. mediterraneus* are both pelagic fish, these species differ from the point of view of living region and feeding behaviour (15). Kalay et al. (22) reported that different fish species contained strikingly different metal levels in their tissues. Similarly, the results presented in this study here showed that metals were more concentrated in grey mullet tissues than that of sea bream (Tables 2 and 3).

Target organs, such as liver, gonads, kidney and gills, have a tendency to accumulate heavy metals in high values, as shown in many species of fish in different areas: in *M. cephalus* in the Mediterranean Sea (23); in *Trachurus mediterraneus* in eastern Mediterranean waters (15,23); in *Mullus barbatus* and *S. aurata* in İskenderun Gulf (14,15). It is generally accepted that muscle is not an organ in which metals accumulate (24). Similar results were reported from a number of fish species showing that muscle is not an active tissue in accumulating heavy metals (25-28). Skin is not much studied in previous works, although it is a consumed part of the fish. Yılmaz (15) indicated that concentrations of heavy metals were higher in all of the skin samples than in muscles. The reason for high metal concentrations in the skin could be due to the metal complexion with the mucus that is impossible to be removed completely from the tissue before the analysis (15). The present results indicate that the lower concentrations of the heavy metals were usually recorded in muscle rather than the skin while the higher values were recorded in the gonads both species and stations. Heavy metal concentrations in the skin of *M. cephalus* were also found higher than *S. aurata*. Gonads, which are known as target organs, have high metabolic activities (25). In this study, the levels of heavy metals of gonads were rather high in both species. As seen in Tables 2 and 3, the gonads revealed higher concentrations of heavy metals than skins and muscles in all the samples studied. The results also indicated that there was a higher metal accumulation in the gonads of *M. cephalus* than in *S. aurata*.

The levels of heavy metal in fish vary in various species and different aquatic environments (16). Moreover, the affiance of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism, and the contamination gradients of water, food and sediment, as well as other factors such as salinity, temperature and interacting agents (21). Initially it was expected that metal concentrations in the tissue of fish from stations B and C would be the highest as they are in the inner regions of the bay, which receive more untreated domestic and industrial wastes from the surrounding environment. The results of this study indicate that generally fish samples from station B displayed the highest metal concentrations in their tissues. Station A appeared to be the cleanest area of the bay; probably, it did not receive much pollutants from industrial and domestic sources (15).

Consequently, it can be concluded that the levels of heavy metals in muscle are at acceptable levels for all of the studied samples in this region. Only the Pb levels in muscle were higher than the acceptable values for human consumption designated by various health organisations (22). Absorbed lead can be distributed quickly to the other tissues and organs (e.g. bones, kidneys, muscle), rather than accumulating in the liver (29). Accumulating of heavy metals in fish viscera may be considered as an important warning signal for fish health and human consumption. The present study shows that precautions need to be taken in order to prevent future heavy metal pollution. Otherwise, these pollutions can be dangerous for fish and human health.

## References


1. Kalay, M., Canlı, M.: Elimination of essential (Cu, Zn) and non-essential (Cd, Pb) metals from tissue of a freshwater fish *Tilapia zilli*. Turkish J. Zool., 2000; 24: 429-436.
2. Ünlü E., Gümgüm, B.: Concentrations of copper and zinc in fish and sediments from the Tigris river in Turkey. Chemosphere, 1993; 26: 2055-2061.
3. Canlı, M., Furness, R.W.: Toxicity of heavy metals dissolved in sea water and influences of sex and size on metal accumulation and tissue distribution in the Norwey lobster *Nephrops norvegicus.* Marine Environ. Res., 1993; 36: 217-236.
4. Larsson, A., Haux, C., Sjöbeck, M.: Fish pshysiology and metal pollution: results and experiences from laboratory and field studies. Ecotox. Environ. Safe., 1985; 9: 250-281.
5. Nemesok, J.G., Hughes, G.M.: The effects of copper sulphate on some biochemical parameters of rainbow trout. Environ. Pollut., 1988; 49: 77-85.
6. Gümgüm, B., Ünlü, E., Tez, Z., Gülsün, Z.: Heavy metal pollution in water, sediment and fish from the Tigris river in Turkey. Chemosphere, 1994; 29: 111-116.
7. Weis, J.S., Weis, P.: Effect of environmental pollutants on early fish development. Rev. Aquat. Sci., 1989; 1: 45-73.
8. Abel, P.D., Papoutsouglou, S.E.: Lethal toxicity of cadmium to *Cyprinus carpio* and *Tlapia aurea*. Bull. Environ. Contam. Toxicol., 1986; 37: 382-386.
9. Salihlioğlu, I., Saydam, C., Yemenicioğlu, S.: Biogeochemical cycle of mercury in the northeastern Mediterranean southern coast of Turkey. Reports Series UNEP, Athens. 1989; Tech. Report No: 32, 37-57.
10. Sunlu, U., Egemen, Ö., Başaran, A.: The Red Mullet *Mullus barbatus* (Linnaeus, 1758) as an Indicator for Heavy Metal Pollution in Izmir Bay (Turkey). 36th CIESM Congress Proceedings, Monte-Carlo, Monaco. 2001; 36: 166.
11. Sunlu, U., Egemen. Ö.: The Investigation of Heavy Metal Levels in *Scorpacna porcus* L. 1758 Living in Izmir Bay. Mediterranean Fisheries Congress. 9-11 April. İzmir. 1977; 487-494.
12. Yazkan, M., Özdemir, F., Gölükçü, M.: Cu, Zn, Pb and Cd content in some fish species caught in the gulf of Antalya. Turk. J. Vet. Anim. Sci., 2002; 26: 1309-1313.
13. Sunlu,U., Egemen,Ö., Kaymakçı, A.: Monitoring of Trace Metal Levels in Demersal Fish *Scorpaena porcus* (L. 1758) Caught From İzmir Bay/Turkey. European Ecology Congress, 19-23 September. Halkidiki/Greece. 1999; 250-251.
14. Kargın, F.: Seasonal changes in levels of heavy metals in tissues of *Mullus barbatus* and *Sparus aurata* collected from Iskenderun gulf (Turkey). Water, Air Soil Pollut., 1996; 90: 557-562.
15. Yılmaz, A.B.: Levels of heavy metals (Fe, Cu, Ni, Cr, Pub and Zn) in tissue of *Mugil cephalus* and *Trachurus mediterraneus* from Iskenderun bay, Turkey. Environ. Res., 2003; 92: 277-281.
16. Canlı, M., Atlı, G.: The Relationship Between Heavy Metal (Cd, Cr, Cu, Fe, Pb, Zn) Levels and Size of Six Mediterranean Fish Species. Environmental Pollution. 2003; 121: 129-136.
17. Pita, C., Gamito, S., Erzini, K.: Feeding habits of the gilthead seabream (*Sparus aurata*) from the Ria Formosa (southern Portugal) as compared to the black seabream (*Spondyliosoma cantharus*) and the annular seabream (*Diplodus annularis*). J. Appl. Ichthyol., 2002; 18: 81-86.
18. Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonese, E.: Fishes of the North-eastern Atlantic and the Mediterranean, Volume III. Richard Clay Ltd., The Chaucer Press, Bungay, United Kingdom. 1986; 1015-1473.
19. Barghigiani, C., Ranieri De, S.: Mercury content in different size of important edible species of the northern Tyrrhenian sea. Mar. Pollut. Bull., 1992: 24: 114-116.
20. Zyadah, M.A.: Accumulation of some heavy metals in *Tilapia zillii* organs from lake Manzalah, Egypt. Turk. J. Zool., 1999: 23: 365-372.
21. Romeo, M., Siau, Y., Sidoumou, Z., Gnassia-Barelli, M.: Heavy metal distrubition in different fish species from the Mauritania coast. Sci. Total Environ., 1999; 232: 169-175.
22. Kalay, M., Ay, Ö., Canli, M.: Heavy Metal Concentrations in Fish Tissues from the Northeast Mediterranean Sea. Bull. Environ. Contam. Toxicol. 1999; 63: 673-681.
23. Abdel-Moniem, M., Khaled, A., Iskander, M.: A Study on Levels of Some Heavy Metals in El-Mex wes Alexandria, Egypt. In: Proceeding of the Fourth Conference on Environmental Protection Must, Alexandria, Egypt. 1994; 155-174.
24. Legorburu, I., Canton, L, Millan. E., Casado. A.: Trace metal levels in fish from Unda river (Spain) Anguillidae, Mugillidae and Salmonidae. Envron. Technol. Lett., 1988; 9: 1373-1378.
25. Karadede, H., Ünlü, E.: Concentrations of some heavy metals in water, sediment and fish species from the Atatürk dam lake (Euphrates), Turkey. Chemosphere, 2000; 41: 1371-1376.
26. Karadede, H., Ünlü, E.: Investigations of the Heavy Metal Accumulations in *Cyprinion macrostomus* (Heckel,1843) (Cyprinidae) from the Atatürk Dam Lake. XIV Turkish Biology Congress, 7-14 September, Samsun, Turkey. 1998; 181-189.
27. Ünlü, E., Sevim-Pakdemir, S, Akba, Ö.: Investigetion of Some Heavy Metal Accumulation in Muscle Tissue and Organs of *Acanthobrama marmid* (Heckel,1843) in the Tigris River. XII. Turkish Biology Congress, Edirne, Turkey, 1994; 327-334.
28. Kargın, F., Erdem, C.: Accumulation of copper in liver, spleen, stomach, intestine, gill and muscle of *Cyprinus carpio.* Doga Tr. J. of Zool., 1991; 15: 306-314.
29. Odzak, N., Zvonaric, T.: Cadmium and lead uptake from food by the fish *Dicentrarchus labrax*. Water Sci. Technol., 1995; 32: 49-55.