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*Research Article*

# Heavy Metals in the Three Fish Species from Honaine Bay in Western Part of Algerian Coast

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**Abstract**

*Contents of heavy metals have been detected in the gonads, muscle, liver and gill of three fish species (Sarpa salpa, Diplodus vulgaris, Trachurus trachurus) in of Honaine coast (in the western coast of Algeria) subsequently the relationships between fish size (length and weight) and metal concentrations in the tissues were investigated by linear regression analysis. The concentrations of some metals in some tissues exceeded the acceptable levels for a food source for human consumption. The results of this study showed that the metals present in the bay were taken up by three fish species through food and water, and regardless of their biological needs showed high metal concentrations. The highest values were found in the liver of Trachurus trachurus (TT). The highest copper concentrations were found in the gonads of Diplodus vulgaris (DV) and the highest nickel concentrations are found in the gonads of Sarpa salpa (SS), The results of a linear regression analysis showed that, except in a few cases, a significant relationship between metal concentrations and fish size were negative. A highly significant (P< 0,001) negative relationship was found between fish length, and zinc, lead and copper concentrations in liver, gill and cadmium concentration in liver of Sarpa salpa (SS), zinc and copper concentration in gill of Diplodus vulgaris (DV) and zinc concentration in gonads of Trachurus trachurus(TT).*

**Keywords:** *Heavy metals, Sarpa salpa, Diplodus vulgaris, Trachurus trachurus, Honaine bay, Algeria, linear regression analysis.*

## 1. Introduction

Fish constitutes an important and cheap source of animal protein to human beings, and a large number of people depend on fish and fishing activities for their livelihood (Özoğul, *et al*, 2006). Increasing human influences through heavy metal pollution have, however, led to the depletion of our fish resources and to a substantial shortage in the nutritive values (Srivastava and Svivastava, 2008). The danger of these heavy metals is their persistent nature as they remain in the biota for a long period of time when released into the environment (Yoon, *et al*, 2008). They can cause a deficiency of marine species' diversity and damage their ecosystem (Austin, 1999; Matta, *et al*, 1999). A wide range of metals and metallic compounds found in the marine environment pose risks to human health through the consumption of seafood, where the contaminant content and exposure are significant (Chan *et al*, 1999, Han *et al*, 1998)

Metals can be taken up by fish from water, food, sediments and also by suspended particulate material (Akbulut and Akbulut, 2010; Abdallah, *et al*, 2008). As fishes have different trophic levels and different sizes and ages, they are considered ideal indicators of heavy metal contamination in aquatic systems (Burger, *et al*, 2002). Numberous reports describe metal residues in wild fish from marine species (Akbulut and Akbulut, 2010; Cicek, *et al*, 2006; Yilmaz, 2003).

The present study is thus to assess the levels of Zn, Pb, Cu, Cd, and Ni in the tissues (gonads, muscle, liver and gill) of three fish species of Honaine bay (*Sarpa salpa*, *Diplodus vulgaris*, *Trachurus trachurus).* These fish species are pelagic or semi pelagic (Khalifa, *et al*, 2010; Saad, 2007). The increase of the metal concentration in fish has an impact on consumers' health status.

## 2. Materials and methods

*2.1 Sampling and analytical procedures*

Three fish species *Sarpa salpa* (SS), *Diplodus vulgaris* (DV*)*, *Trachurus trachurus (*TT*)* were purchased from

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local fishermen at Honaine bay between April and June 2010. After identifying the species, samples were immediately kept in precleaned polythene bags, which were sealed and kept in an ice box and transported to the laboratory. Total length and weigh was measured for each fish. After that, gonads, muscles, liver and gill were removed by plastic knife and weighted. After dissection, all the samples were labelled according to their species. The tissues were separately dried in the laboratory oven at 110°C for 3 hours. The dried tissue was reduced into fine powder in a pestle and mortar and the resulting powder was selected, using a plastic sieve with 0, 63 µm opening size and was stored in a muffle furnace at 450°C for 15 min. Each sample was removed and was treated with 1ml nitric acid and was put back on again in a muffle furnace at 350°C for 90 min.

After this process, the samples were transferred to 25 ml flanks and we added double distilled water until 25 ml. The solution was filtered with filter papers (0, 45 µm).

Concentrations of metals were determined by using Atomic Absorption Spectrophotometer (AAS) (Rayleigh WFX-130). The following absorption lines were used; (zinc 213, 9 nm, lead 283, 3 nm, copper 324, 8 nm, and cadmium 228, 8 nm).

*2.2 Area studies*

Honaine bay is situated 60 km north west of Tlemcen, at the western-Mediterranean coast of Algeria with an area of approximately 200 km$^2$, a length of 20 km and a width of approximately 10 km. During In summer, sea temperature rises up to 30°C and falls down to up 12°C in winter.

Domestic discharges and pesticides are the main source of pollution. No industrial effluents are diverse in Honaine bay. In the 2009, this area became a desalinisation station. It pointed out that the bay may have risks due to pollution or pesticide run-off, so environmental conditions and levels of pollution in the areas suggested for fishing should be closely monitored.

Fishing is the main activity in the region. *Sarpa salpa*, *Diplodus vulgaris*, *Trachurus trachurus* constitute 20 % of the total catch and approximately 50 % of the economical important catch in the bay (DPRH, 2010).

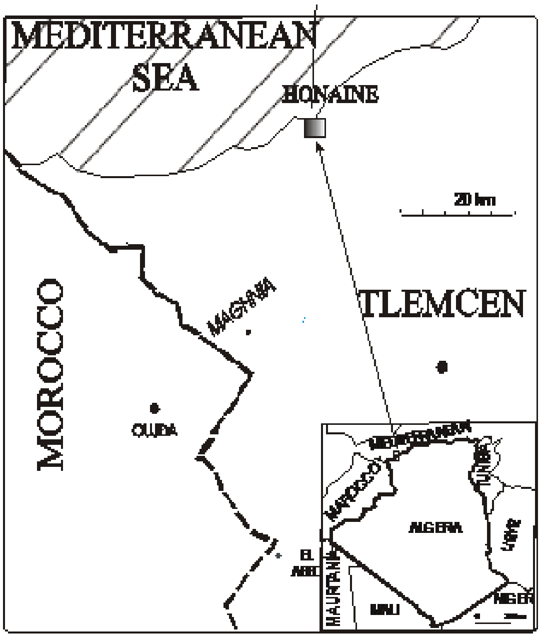


**Figure 1**: Honaine (Algeria) map, sampling station

**Table 1:** the numbers of fishes sampled, the average total length and weight ranges and their relationships.

| Fish | *n* | L.ranges | W. ranges | Equation a | R value |
|---|---|---|---|---|---|
| SS | 32 | 15-23 | 41-195 | Y = 12,64 + 0,054X | 0,99 |
| | | 18,79 ± 2,58 | 114,55 ± 47,62 | | |
| DV | 32 | 14,0-18,9 | 40-1026 | Y = 11,25+0,075X | 0,98 |
| | | 15,89 ± 1,42 | 61,56 ± 18,55 | | |
| TT | 32 | 18,8-24,7 | 101-168 | Y= 9,27+ 0,091X | 0,99 |
| | | 21,50±1,53 | 134,64±16,68 | | |

Y is total fish length (cm) and X is total fish weight (g)

**Table 2 :** the average metal concentrations (Zn, Pd, Cu, Cd and Ni) in tissues (gonads, muscle, liver and gill) of fishes, *Sarpa salpa(SS)*, *Diplodus vulgaris(DV)*, *Trachurus trachurus(TT)* and their standard deviations.

| Fish | Tissue | Zn (mg/kg) | Pb(mg/kg) | Cu mg/kg | Cd (mg/kg) | Ni(mg/kg) |
|---|---|---|---|---|---|---|
| SS | Gonads | 0,139 ± 0,057 | 0,037 ± 0,021 | 12,651 ± 4,195 | 0,072 ± 0,084 | 6,088 ± 3,758 |
| DV | | 0,096 ± 0,064 | 0,259 ± 0,180 | 48,668 ± 25,880 | 0,769 ± 0,445 | 0,021 ± 0,014 |
| TT | | 0,573 ± 0,277 | 0,6233 ± 0,2505 | 7,081 ± 2,472 | 0,099 ± 0,060 | 4,375 ± 1,456 |
| SS | Muscle | 0,856 ± 0,244 | 0,005 ± 0,001 | 1,723 ± 0,149 | 0,019 ± 0,006 | 0,776 ± 0,528 |
| DV | | 2,910 ± 0,394 | 0,008 ± 0,001 | 1,684 ± 0,216 | 0,034 ± 0,013 | 1,838 ± 0,622 |
| TT | | 0,272 ± 0,123 | 0,2166 ± 0,027 | 2,970 ± 0,269 | 0,002 ± 0,001 | 1,210 ± 0,489 |
| SS | Liver | 0,495 ± 0,181 | 0,015 ± 0,007 | 4,714 ± 2,141 | 0,047 ± 0,021 | 1,173 ± 1,270 |
| DV | | 0,302 ± 0,167 | 0,093 ± 0,044 | 16,781 ± 6,893 | 0,357 ± 0,172 | 0,221 ± 0,107 |
| TT | | 1,902 ± 0,552 | 1,9597 ± 0,541 | 20,488 ± 5,772 | 0,000 ± 0,000 | 14,622 ± 5,303 |
| SS | Gill | 0,845 ± 0,471 | 0,015 ± 0,007 | 3,461 ± 1,478 | 0,045 ± 0,031 | 1,291 ± 0,838 |
| DV | | 0,724 ± 0,243 | 0,030 ± 0,010 | 5,754 ± 1,743 | 0,101 ± 0,063 | 1,398 ± 0,545 |
| TT | | 0,487 ± 0,333 | 0,469± 0,101 | 5,164 ± 0,867 | 0,002 ± 0,001 | 1,091 ± 0,729 |

*2.3 Statistical analysis*

The determined heavy metal contents in the gonads, muscle, liver and gill of each fish were evaluated statistically using analysis of variance (one way ANOVA) technique (MINITAB software version 15.0 program), and the linear regression analyses were applied to data to compare the relationship between size and heavy metal concentrations in the tissues.

## 3. Results and discussion

Table 1 shows the numbers of fishes sampled, the average total length and weight ranges and their relationships.

Table 2 shows the average metal concentrations (Zn, Pd, Cu, Cd and Ni) in tissues (gonads, muscle, liver and gill) of fishes, *Sarpa salpa*, *Diplodus vulgaris*, *Trachurus trachurus* and their standard deviations.
Metal concentrations among the tissues from fishes were compared statistically using one way ANOVA. All comparisons were statistically significant at P<0,001.

The average concentrations in gonads, liver and gill of *Sarpa salpa* followed respectively the sequences Cu > Ni > Zn > Cd > Pb, in muscle Cu > Zn > Ni > Cd > Pb while those of *Diplodus vulgaris* followed respectively the order in gonads Cu > Cd > Pb >Zn > Ni, in muscle Zn > Ni > Cu > Cd > Pb, in liver Cu > Cd > Ni > Pb , and in gill Cu > Ni > Zn > Cd > Pb, while those of *Trachurus trachurus* followed respectively the orders Cu > Pb> Ni > Zn > Cd. Different tissues showed different capacities for accumulation of heavy metals.

Cadmium was not detected in liver of *Trachurus trachurus* and zinc, lead, copper and nickel were the highest. Zinc varied significantly in the gonads (P<0,05) and in the liver (P<0,01) from one species to another. Likewise in the gill of *Trachurus trachurus* nickel concentrations varied significantly (P<0,01).

Copper concentrations were higher in the gonads of *Diplodus vulgaris* ranged from 5,51 to 92,92 mg/kg. Zn and Ni levels in muscle and Ni in the gill of *Diplodus vulgaris* ranged from 2,196 to 3,856 mg/kg, 0,706 to 2,834 mg/kg and varied 0,702 to 3,585 mg/kg.

The highest Ni concentrations were recorded in the gonads and Zn in the gill of *Sarpa salpa* ranged between 1,499 - 20,228 mg/kg and 0,375 - 1,911 mg/kg. Ni concentrations varied significantly (P<0,05) in gonads. Zinc, lead, copper and cadmium concentrations varied significantly (P<0,05) in the liver of *Sarpa Salpa*. Also, in the gill of *Sarpa Salpa* zinc, lead and nickel concentrations varied significantly (P<0,05, P< 0,001, P< 0,01).

The average concentration of Zn in the gonads of the fishes species varies from a minimum of 0,096 ± 0,064 mg.kg$^{-1}$ in *Sarpa salpa* to a maximum of 0,576 ± 0,222 mg/kg in *Trachurus trachurus.* In the muscle the mean Zn concentration varies from a minimum of 0,272 ± 0,123 mg/kg in *Trachurus trachurus* to a maximum of 2,910 ± 0,394 mg.kg$^{-1}$ in *Diplodus vulgaris.* In the liver the average Zn concentration varies from a minimum of 0,495 ± 0,181 mg/kg in *Sarpa salpa* to a maximum of 1,902 ± 0,552 mg/kg in *Trachurus trachurus.* In the gill the average Zn concentration varies from a minimum of 0,487 ± 0,333 mg.kg$^{-1}$ in *Trachurus trachurus* to a maximum of 0,845 ± 0,471 mg/kg in *Sarpa salpa .*

The average values obtained for Zn in this study in all organs and in three fishes were below the 67,1 mg/kg, values of IAEA- 407, (Whyse, 2003) thus indicating that the fishes examined were free from Zn related toxicity (Fig 2).

The average concentration for Pb in three fish species studied varied from a minimum of 0,037 ± 0,021 mg/kg in gonads, 0,005 ± 0,001 mg/kg in muscle, 0,015 ± 0,007 mg/kg in liver and gill respectively of *Sarpa salpa* to a maximum value of 0,6233 ± 0,2505 mg/kg in gonads, 0,2166 ± 0,027 mg/kg in muscle, 1,9597 ± 0,541 mg/kg in liver, 0,469± 0,101 mg/kg in gill of *Trachurus trachurus* (Table 2). Lead concentrations were higher in all organs of *Trachurus trachurus* (Fig 2). The values obtained for Pb in *Trachurus trachurus* the present investigation, were above the 0,12 mg/kg, recommended by IAEA- 407, (Whyse, 2003) for Pb in food fish.

High average concentration of Cu was also observed in gonads, liver and gill of all the fish species studied (Table 2) and the average concentration varied from minimum of 7,081 ± 2,472 mg/kg in gonads of *Trachurus trachurus* to a maximum value of 48,668 ± 25,880 mg/kg in gonads of *Diplodus vulgaris*. Cu concentrations varied from minimum 1,723 ± 0,149 mg/kg in muscle and 4,714 ± 2,141 mg.kg$^{-1}$ in liver and 3,461 ± 1,478 mg/kg in gill respectively of *Sarpa Salpa* to a maximum value of 2,970 ± 0,269, mg.kg$^{-1}$ in muscle and 20,488 ± 5,772 mg/kg in liver of *Trachurus trachurus* and 5,754 ± 1,743 mg/kg in gill of *Sarpa salpa.* The values obtained for Cu in gonads, liver, and gill were above 3,28 mg/kg recommended by IAEA-407, (Whyse, 2003). Indicating that these fishes could pose health problem to consumers.

High average concentration of cadmium was observed in gonads, liver and gill of *Diplodus vulgaris* (Table 2). The mean concentration varied from minimum of 0,072 ± 0,084 mg/kg, 0,019 ± 0,006 mg/kg, 0,047 ± 0,021 mg/kg respectively in gonads, muscle and gill of *Sarpa salpa*, and 0,002 ± 0,001 mg/kg in gill of *Trachurus trachurus*, and maximum of 0,769 ± 0,445 mg/kg, 0,034 ± 0,013 mg/kg, 0,357 ± 0,172 mg/kg 0,101 ± 0,063 mg/kg respectively in gonads, muscle, liver and gill of *Diplodus vulgaris* (Table 2). Cadmium was not detected in liver of *Trachurus trachurus* (Fig 2). The mean values obtained for Cd in this study in all organs of *Diplodus vulgaris* were above the 0,189 mg/kg, values of IAEA- 407, (Whyse, 2003). This implies that *Diplodus vulgaris* could pose cadmium related health problem to consumers

The average concentration for Ni in three fish species studied varied from a minimum of 0,021 ± 0,014 mg/kg and 0,221 ± 0,107 mg/kg respectively in gonads and in liver of *Diplodus vulgaris* 0,776 ± 0,528 mg/kg in muscle of *Sarpa salpa*, 1,091 ± 0,729 mg/kg in gill of *Trachurus trachurus* to a maximum value of 6,088 ± 3,758 mg.kg$^{-1}$ in gonads of *Sarpa salpa*, 1,838 ± 0,622 mg/kg in muscle 1,398 ± 0,545 mg/kg in gill of *Diplodus vulgaris*, 14,622 ± 5,303 mg/kg in liver of *Trachurus trachurus* (Table 2). Nickel concentrations were higher in all fish studied (Fig 2).

The values obtained for Ni in all fish species in the present investigation were above 0,6 mg/kg, recommended by IAEA-407 (Whyse, 2003), thus indicating that these fishes may pose Ni related health hazard like cancer id of lungs and kidneys of the consumers (Jackson and Morris, 1989). Target organs, such as the gonads muscle, liver, and gill, are metabolically active tissues and accumulate heavy metals of higher levels, as was observed in Experimental (Allan, 1994, Kalay and Erdem 1995) and Field Studies (Unlu *et al*, 1996), Karadede and Unlu, (2000). From other research, it is clear that the target organs have a tendency to accumulate heavy metals (copper, cadmium, lead, nickel and zinc) in high values, as shown in many species of fish in different areas. The concentrations of metals in gills reflect those of metals in water. Muscle has been found to be an inactive tissue in accumulating heavy metals (Yilmaz, 2003).

Table 3-5 show the relationship between metal concentrations and fish size. The relationship between metal levels and weight were also carried out and the significations of data were exactly the same except for a few cases and only these indicated in the tables.
Significant negative relationships were found between fish *Sarpa salpa* (SS) length (and weight) and lead and copper levels in liver and gill ($P<0,001$) respectively, lead level in the gonads ($P< 0,05$), and cadmium levels in the liver ($P<0,001$) , and in the gill ($P<0,01$), nickel levels in the liver ($P<0,05$), and in the gill (0,01) in *Sarpa salpa* (Table3). Also there was some positive relationship between zinc levels in the liver and in the gill and length ($P<0,001$).

The tissues of *Diplodus vulgaris* (DV) also showed negative relationships between length and lead levels in the gonads ($P<0,01$) in the liver ($P<0,05$) and in the gill ($P<0,01$), copper levels in the gill ($P<0,001$), cadmium levels in the muscle and the gill ($P<0,01$). Similarly, copper and cadmium levels in the gonads also showed a negative relationship ($P<0,05$) with weight but not with length ($P>0,05$) (Table 5).

In *Trachurus trachurus* (TT), there was positive relationship between zinc levels in gonads and length ($P< 0,001$). Lead, cadmium and nickel levels also showed a positive relationship ($P<0,05$) in gonads and nickel levels in the gill ($P<0,05$). The muscle, liver and gill tissues of *Trachurus trachurus* (TT) did not show any significant relationship ($P>0,05$) between metals and size, except nickel in the gill, where there was a significant positive relationship ($P<0,05$) (Table 4).
Average metal concentrations in organ study of metals in all organs of each fish species showed variations. Statistical comparisons revealed that metals concentrations were significantly different in each tissue between different fish species (Kalay *et al*,1999). This may be related to the differences in ecological needs, swimming behaviours and the metabolic activities among different fish species. The differences in metals concentrations of the tissues might be the result of their capacity to induce metal-binding proteins such as metallothioneins.

Liang *et al*, (1999) studied metal (Zn, Cu, Cd, Cr, Pb, Ni) concentrations in various polycultured fished species and found that metals in fish viscera were generally negatively correlated. It has been suggested that metal metabolism in fish played an important role in metal accumulation in fish viscera. Another interesting results was the high lead concentrations in liver, especially of *Trachurus Trachurus* (1,96 mg/kg). This may be related to their feeding behaviour. *Trachurus Trachurus* are filter- feeding fish that particles in surface waters with their gill rakers and active in swimming.

**Table 3:** Relationship between metal concentrations and fish (*Sarpa salpa)* size

| Tissue | Data | Zinc | Lead | Copper | Cadmium | Nickel |
|---|---|---|---|---|---|---|
| Gonad | Equation | Y=0,0004X+0,133 | Y=-0,0037X+0,107 | Y=-0,3694X+19 ,59 | Y=-0,0054X+0,173 | Y=0,281X+0,814 |
| | R value | 0,02 | -0,45 | -0,23 | -0 ,16 | 0,19 |
| | P value | NS | * | NS | NS | NS |
| Muscle | Equation | Y=-0,0063X+0,974 | Y=-3E-05X+0,0054 | Y=-0,0073X+1,86 | Y=-0,0004X+0,026 | Y=-0,0004X+0,0257 |
| | R value | -0,07 | -0,15 | -0,13 | -0,15 | -0,15 |
| | P value | NS | NS | NS | NS | NS |
| Liver | Equation | Y=0,054X-0,519 | Y=-0,0023X+0,0579 | Y=-0,641X+16,78 | Y=-0,0048X+0,137 | Y=-0,202X+4,96 |
| | R value | 0,77 | -0,79 | -0,77 | -0,59 | -0,41 |
| | P value | *** | *** | *** | ***(**) | * |
| Gill | Equation | Y=0,126X-1,52 | Y=-0,0022X+0,0568 | Y=-0,48+12,49 | Y=-0,0063X+0,164 | Y=-0,232X+5,64 |
| | R value | 0,69 | -0,83 | -0,84 | -0,52 | -0,71 |
| | P value | *** | *** | *** | ** | ** |

In the equations, Y is metal concentration (mg/kg D.W.) and X is total length (cm), Asterisks indicate significant results, NS, not significant, P > 0,05
* P < 0,05, ** P < 0,01, *** P< 0,001

**Table 4:** Relationship between metal concentrations and fish (*Trachurus trachurus)* size

| Tissue | Data | Zinc | Lead | Copper | Cadmium | Nickel |
|---|---|---|---|---|---|---|
| Gonad | Equation | Y=-0,1523X-2,701 | Y=0,089X-1,295 | Y=-0,314X+0,33 | Y=0,02X-0,33 | Y=0,433X-4,9346 |
| | R value | 0,84 | 0,51 | 0,19 | 0,51 | 0,45 |
| | P value | *** | ** | NS | ** | ** |
| Muscle | Equation | Y=0,002X+0,236 | Y=0,001X+0,197 | Y=0,023X+2,48 | Y=0,0005X-0,009 | Y=0,012X+0,95 |
| | R value | 0,02 | 0,05 | 0,13 | 0,29 | 0,04 |
| | P value | NS | NS | NS | NS | NS |
| Liver | Equation | Y=0,0562X+0,692 | Y=0,019X+1,5604 | Y=1,053X+2,16 | Y=0 | Y=-0,5498X+26,44 |
| | R value | 0,16 | 0,05 | 0,28 | - | -0,16 |
| | P value | NS | NS | NS | - | NS |
| Gill | Equation | Y=0,0357X-0,281 | Y=-0,0013X+0,4983 | Y=0,1083X+2,8354 | Y=0 | Y=0,193X-3,0543 |
| | R value | 0,16 | -0,02 | 0,19 | - | 0,40 |
| | P value | NS | NS | NS | - | * |

In the equations, Y is metal concentration (mg/kg D.W.) and X is total length (cm), Asterisks indicate significant results, NS, not significant, P > 0,05
* P < 0,05, ** P < 0,01, *** P< 0,001

**Table 5:** Relationship between metal concentrations and fish *(Diplodus vulgaris*) size

| Tissue | Data | Zinc | Lead | Copper | Cadmium | Nickel |
|---|---|---|---|---|---|---|
| Gonad | Equation | Y=0,0238X-0,2822 | Y=-0,0717X+1,3996 | Y=-5,6109X+137,85 | Y=-0,0951X+2,279 | Y=-0,0006X+0,0312 |
| | R value | 0,53 | -0,57 | -0,31 | -0 ,30 | -0,07 |
| | P value | ** | **(***) | NS(*) | NS(*) | NS |
| Muscle | Equation | Y=-0,0094X+2,759 | Y=-0,0001X+0,0099 | Y=-0,0422X+2,3554 | -0,0046X+0,1062 | Y=-0,1238X+3,8053 |
| | R value | 0,03 | -0,14 | -0,28 | -0,51 | -0,28 |
| | P value | NS | NS | NS | ** | NS |
| Liver | Equation | Y=0,0384-0,3078 | Y=-0,0128X+0,2963 | Y=-0,832X+30 | Y=-0,0282X+0,805 | Y=0,0298X-0,2525 |
| | R value | 0,33 | -0,41 | -0,17 | -0,23 | 0,40 |
| | P value | NS | * | NS | NS | * |
| Gill | Equation | Y=0,1051-0,8837 | Y=-0,0042X+0,0964 | Y=-0,714X+17,145 | Y=-0,0213X+0,444 | Y=0,0695X+0,2854 |
| | R value | 0,62 | -0,58 | -0,59 | -0,49 | 0,18 |
| | P value | *** | ** | ***(**) | ** | NS |

In the equations, Y is metal concentration (mg/kg D.W.) and X is total length (cm), Asterisks indicate significant results, NS, not significant, P > 0,05
*P < 0.05, ** P < 0.01, *** P< 0,001

The *Sarpa salp*a (Linnaeus, 1758), is a fish found along rocky coasts covered with algae. It is a protogynous hermaphrodite which sexually mature at approximately 20 cm lengths, and spawns at the beginning of fall and in winter (Jardas, 1996; Van der Wait and Mann, 1998). Under natural living conditions, it is mostly a herbivore, changing its food habit by the age and flesh chemistry at the same time (Joubert and

Hanekom, 1980; Gerking, 1984, Antonić *et al*, 1994; Tomec *et al*, 1998).

This study mainly aimed to investigate relationships between heavy metal concentrations in a tissue and fish length and weight. Results showed that there were negative relationships between fish sizes and metal levels in most cases of *Sarpa salpa* and *Diplodus vulgaris.* The data showed that the positive relationships were found only between zinc levels in the liver and gill of the *Sarpa salpa* and also zinc levels in gonads and gills of *Diplodus vulgaris* and in some cases of *Trachurus trachurus*. The results of comparisons between metals and the two size parameters showed the same trend in all fish species except a few cases (Table 3-5).

The negative relationships between heavy metal levels in the tissues and fish sizes were generally supported in the literature (Nussey *et al*, 2000). Authors showed that accumulation of metals ( Cr, Mn, Ni and Pb) decreased with an increase in the length of fish *labeo umbratus*. Al-Yousuf et al., (2000) found that the average metal concentrations in tissues of female fish were higher than those in male fish, indicating the differences in metabolic activities of the two sexes. Widianarko *et al*, (2000) investigated the relationship between metal (Pb, Zn, Cu) concentrations and fish size. They indicated that body concentrations of copper and zinc are regulated and maintained at a certain concentration.

Liang *et al*,(1999) studied metal (Zn, Cu, Cd, Cr, Pb, Ni) concentrations in various polycultured fish species and found that metals in fish viscera negatively correlated (except Zn in viscera of common carp. It has been suggested that metal metabolism in fish played an important role in metal accumulation in fish viscera.

It is well known that one of the most important factors that play a significant role in heavy metal accumulation in marine animals is the metabolic activity (Heath, 1987; Langston, 1990, Roesijadi and Robinson 1994). It is also known that the metabolic activity of a young individual is normally higher than that of an older one. Thus, metal accumulation was shown to be higher in younger individuals than in older ones (Elder and Collins, 1991; Douben, 1989, Nussey *et al*, 2000; Widianarko *et al*, 2000).

One explanation for negative relationships between metal concentrations and size found in this study may be the difference in metabolic activity between younger and older fish. The net accumulation of heavy metals in the organism is the result of the difference between uptake and depuration, and this is the most important factor in metal accumulation. Therefore, the result of this study may also lead to say that heavy metal concentrations in southwest of the Mediterranean Sea are in such levels that the fishes may control their tissue levels with the growth. High concentration of metals in water can also retard fish development causing possible alternations in fish size (Friedmann *et al*, 1996; Heath, 1987; Weis and Weis, 1989). Heath (1987) indicated that the fish development can be affected by the presence of heavy metals in water and especially the early life stages such as the hatching time, the larval development and the juvenile growth as they are more sensitive than the mature stage.

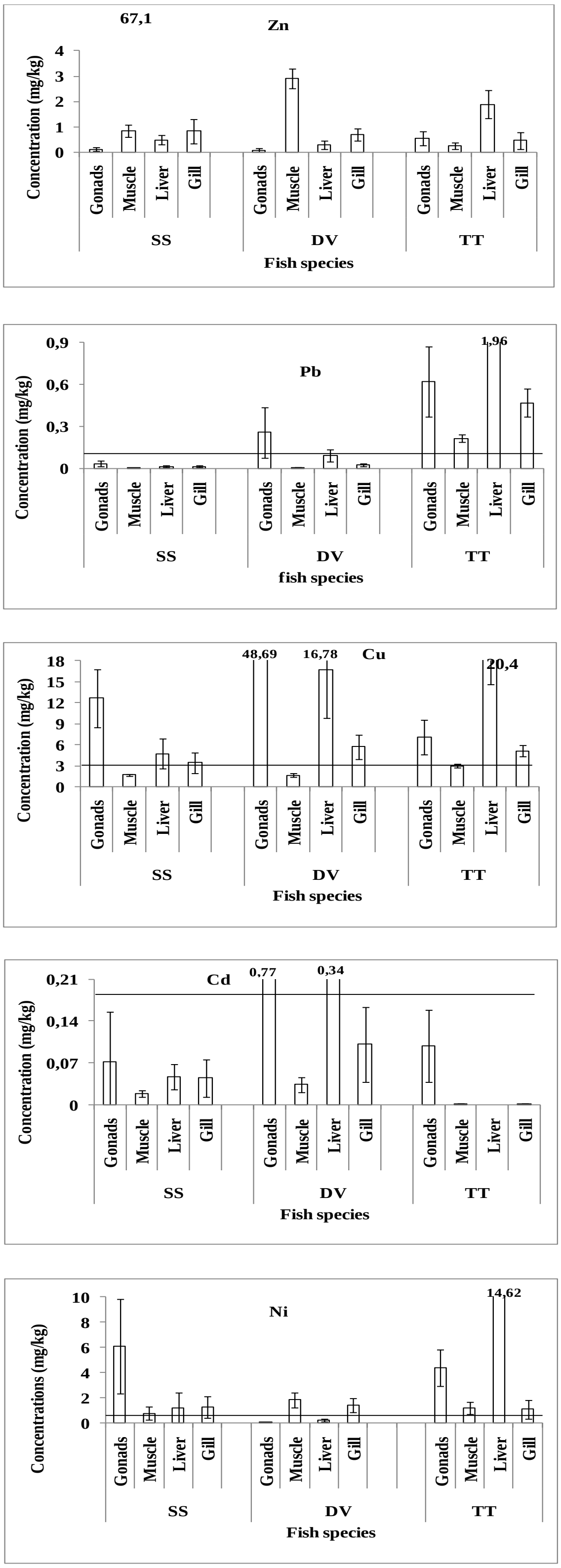


**Figure 2:** The average metal concentrations (Zn, Pd, Cu, Cd and Ni) in tissues (gonads, muscle, liver and gill) of fishes, *Sarpa salpa*, *Diplodus vulgaris*, *Trachurus trachurus* and their standard deviations.

Previous studies also indicated that different concentrations of heavy metals in different fish species might be a result of different ecological needs, metabolism and feeding patterns (Yimaz, 2003).

## Conclusion

This study shows that while the concentration of Pb, Cu, Cd and Ni both in liver and gonads of the fish species were beyond the IAEA-407 (Wyse *et al*, 2003) prescribed limits, Zn was within the limits. These metals could pass to humans through the food chain and predispose the consumers to possible health hazards. Periodic monitoring of these and other heavy metals in fishes to ensure continuous safety of people in the area is recommended. Safe disposal of domestic wastes should be practised and if possible recycled to prevent these metals and other contaminants from going into the environment.

Further studies on the concentration of heavy metals in other fish tissues (brain, kidney, intestine and heart) are recommended.

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