

## **Determination of Some Heavy Metals in Tissues and Organs of Three Commercial Fish Species at Al-Hudaydah, Red Sea Coast of Western Yemen**

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**Abstract:** It is well known that the fish remains one of the most popular staple foods not only for the coastal communities but also globally. It is consumed by many people of the world because it has high protein content and a rich source of polyunsaturated fatty acids such as omega-3- fatty acids which are important for our diet albeit our bodies cannot make them from scratch because they support normal metabolism and good health. The occurrence of heavy metals in fish from certain coastal areas has become a major cause of concern in many countries. An assessment of heavy metals contamination in three fish species (*Arius* sp., *T. tanggol* and *Mugil* sp.) were made by using Atomic Absorption Spectrophotometer (AAS). The heavy metals examined in fish under this investigation namely: Nickel (Ni), Cobalt (Co), Copper (Cu), Cadmium (Cd) and Manganese (Mn). Results indicated that fish species revealed variations among heavy metal contents in both tissues and organs. All metals in white muscles (tissues) ranged between 0.6-7.25, 1.75-7.95 and 1.50-6.55 µg/g dry wt., for *Arius* sp., *T. tanggol* and *Mugil* sp. respectively. Similarly, the total heavy metals concentration from the fish under this investigation can be ordered as follows: *Arius* sp. > *T. tanggol* > *Mugil* sp. i.e. 109.35, 106.00 and 96.20 µg/g dry wt. respectively. Results obtained from fish organs indicated that the three fish species exhibited variations in heavy metal concentrations. Although, values of heavy metals obtained from tissues in the present study were within the acceptable worldwide range, however, they were lower than those reported in parts from other regions of the world which are considered as polluted areas. The occurrence of heavy metals in tissues and organs of the examined species may be due to the anthropogenic activities, feeding behavior of the fish species, fat content and of any other environmental factors in the study area. Moreover, the difference in heavy metal accumulation in different organs may be due to the differences in their physiological and biochemical functions. In order to control the heavy metals pollution in this area further and continuous critical investigations are urgently needed.

**Key words:** Fish • Heavy Metals • Red Sea • Western Yemen

### **INTRODUCTION**

The current catastrophic and tragic environmental pollution syndrome is one of the greatest problems that the world is facing today and it is evidently worsening with time, causing irreparable chemical pollution damage and serious threats to all humans and the environment biota at large, thus complicating the worldwide contemporary scare of the climate change. To-date, the state-of-the-art vibrant well documented research by

eminent scholars proved that the chemical pollution is emanating from a product of man's activities in urbanization, industrialization, population growth, various economic reasons and thriving neo-technologies. The omnipresent urban life during this time and age has concentrated people in metropolitan and cosmopolitan cities, which have resulted in increased pollution of the air, as a result of the burning of fossil fuels. This predicament is aggravated by the extreme streaming onslaughts by tons of organic pollution

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adulterating the fresh water in rivers and underground resources from organic pollutants in the form of organic sewage. The over-all effects of this chemical pollution has already resulted in a plethora of diseases and illnesses in humans albeit killing fish has become crucial in destroying the fauna and flora of wildlife in the rivers and coastal waters [1-8].

These variegated anthropogenic activities such as mining, smelting, refining, energy production, industrial and vehicular emissions, agricultural operations, sewage discharge and waste disposal have been responsible for the unequivocal rapid increase of aquatic pollution. The anthropogenic pollutants are ultimately washed out of the air by rain onto land or on the surface of water [9]. The contaminants entering aquatic ecosystems may not directly damage organisms, but might lead to the ill-effects through the bioconcentration, bioaccumulation and food chain alterations within ocean populations and eventually threatening the health of humans through seafood consumption [7].

Heavy metals are the most dangerous of the anthropogenic environmental pollutants due to their toxicity, widespread prevalence, persistently high levels in the environment and their subsequent accumulation in the aquatic fauna and flora, which in turn may enter into the human's food chain [10-12]. The toxic effects of heavy metals are becoming high in the priority list of environmentalists and human health concerns over the last few decades [13]. Many field studies of metal accumulation in fish living in polluted waters showed that considerable amounts of various metals may be deposited in fish tissues [14-17]. Various metals may be accumulated in fish body in different amounts which might be due to the different affinities of metals on certain fish tissues including different metals uptake, deposition and excretion rates [18].

The global consumption of fish and the derivatives of fish products have generally increased during the recent decades, due to the welcomed change in the human's diet from animal protein to fish protein with reduced cholesterol levels. Fish are also considered one of the most important nutritional groups on the top of the hierarchy of the aquatic food chain, therefore they deserve to be provided and tended with the best vigilant care of water quality [19, 20].

Although the pollution of aquatic environment by heavy metals was well documented worldwide, however, few studies were conducted around the coastal area of the Republic of Yemen. The main objectives of this study were to provide critical information on heavy metals concentration through determining and comparing the

level of heavy metals in white muscles and some key organs including (the gills, liver and gonads) from samples of three commercially local fish species, collected from Al- Hudaydah, Red Sea Coast, Western Republic of Yemen (ROY).

## MATERIALS AND METHODS

Fig. 1 shows the location map of the study area at Al-Hudaydah. The selection of the study area was based on many important factors among them the sewage effluent disposal plant, which is located to the south of the study area and the power plant station at Ras-Kathib which is located north of Al- Hudaydah commercial port. In addition to that the study area receives huge amounts of wastewater from a treatment plant which discharges large quantities of untreated sewage to the north of Al-Hudaydah commercial port and moreover, the location of the fish market is situated to the south of the city.

**Fish Samples:** Three commercial fish species, namely *Arius* sp., *Thunus tanggol* and mullet *Mugil* sp. were collected directly from the coastal area along the Red Sea coast at Al-Hudaydah sea port. The recovered fish samples were immediately kept in clean polythene bags, which were sealed and kept carefully on icebox and brought to the lab for further investigations and analysis.

**Metal Ion Extraction:** In this study, fish composites (of similar size and weight) samples (fillets) of white muscle (edible parts), liver, gonads and gills samples weighing 5-6 g were dried to a constant weight at 60°C for 18 h. The dried samples were grinded into fine powder in a pestle and mortar and were passed through a plastic sieve (0.2 mm mesh size). Subsequently one gram of the powdered samples was taken in a beaker and digested with 50 ml of concentrated nitric acid and perchloric acid (3:1) at 60°C on a hot plate until the contents came to about 5.00 cm<sup>3</sup> and all the material was dissolved. It was then filtered through Whatman's filter paper No. 40, washed with distilled water, collected in a 50 ml volumetric flask and made up to 50.00 cm<sup>3</sup> with distilled water. A reagent blank was also run simultaneously for the comparison purposes.

**Preparation of Standard Metal Ion Solutions:** Stock solutions (1000 mg/l) of each of the metal ions were obtained from Perkin Elmer, USA. The working standards and specifications of these solutions were prepared by appropriate dilutions in de-ionized water.



Fig. 1: Shows the location map of the study area Al-Hudaydah commercial port, Red Sea coast, Western region of Yemen

**Sample Analysis:** Analysis of heavy metal contents extracted from fish samples from muscle tissue, gills, liver and gonads was performed with the atomic absorption spectrophotometer (Perkin Elmer Analyst 410-Atomic Absorption Spectrometer-AAS: Double beam mode) equipped with single element hollow cathode lamp and air-acetylene burner.

**Calculations:** The amount of the heavy metals in the samples was calculated according to FAO/SIDA 39 as follows:

$X = CV/W$ , where  $X$  = Amount of element in sample mg/kg;  $C$  = Concentration read out from AAS (g);  $V$  = Volume of solution (ml) and  $W$  = Weight of sample in grams. The heavy metals concentrations were expressed as  $\mu\text{g/g}$  dry wt.

## RESULTS AND DISCUSSION

Heavy metals are those elements having atomic weight between 63.54 and 200.59 [21] and a specific gravity greater than 4.0. Many organisms require trace

amount of heavy metals such as Co, Cu, Fe, Mn, Mo and Zn for their normal metabolism and physiological activities. However, excessive levels of these elements can be detrimental to these organisms. The term "heavy metals" refers to any metal or element which is relatively of high density and toxic or poisonous even at low levels. The heavy metal include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu) and iron (Fe). The presence of heavy metals in our environment has been of great concern because of their toxicity when their concentration is more than the permissible level. These metals normally enter into marine environment through different ways like human anthropogenic and industrial activities... etc. [22].

The marine environment may be contaminated with effluent wastes loaded with heavy metals from both anthropogenic and natural weathering processes. Such inputs could be the results of treated and/or untreated municipal and industrial wastes, agricultural runoff and deposition from the atmosphere [7]. Nevertheless, in the following sections, we will discuss our findings in one tissue (white muscles) and some key organs (gills, livers, gonads) of fish species.

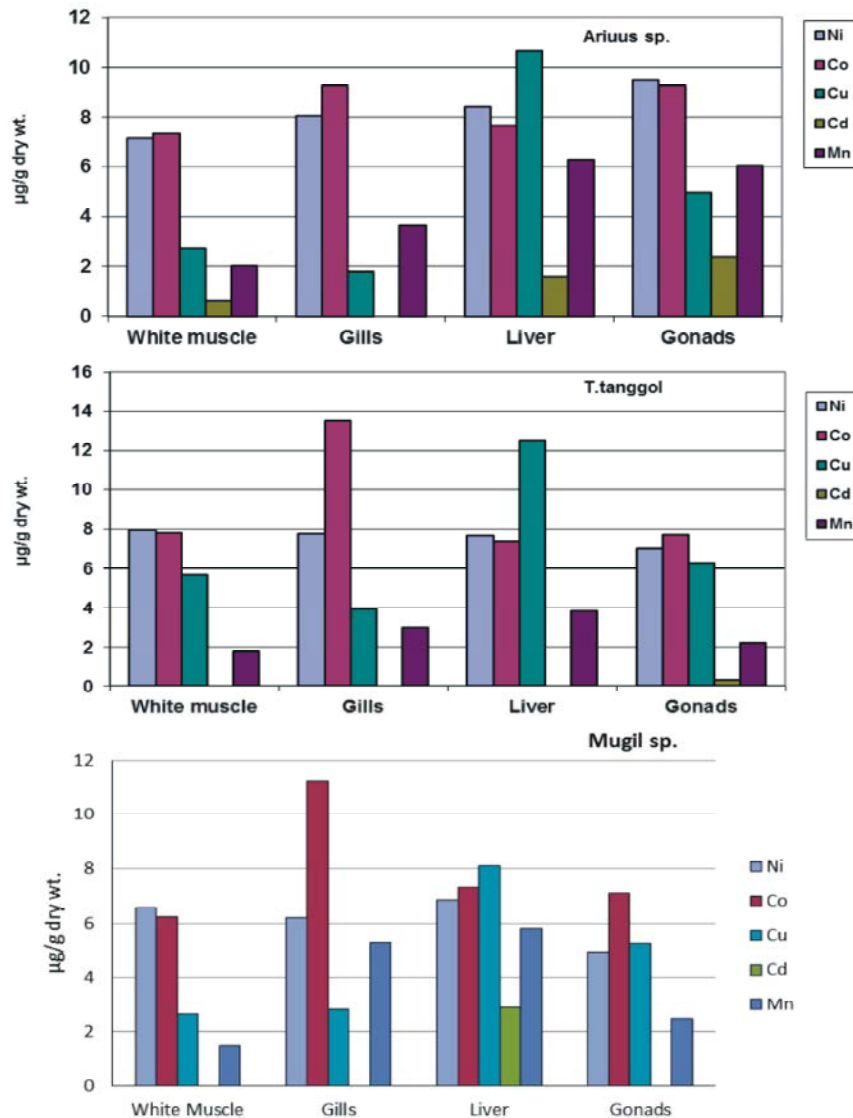


Fig. 2: The concentration of heavy metals ( $\mu$  /g dry wt.) from the three commercial fish species (*Arius* sp., *T. tanggol*, *Mugil* sp.) collected at Al-Hudaydah coastal area, Western region of Yemen

**Arius sp.:** Table 1. and Fig. 2 show the mean concentration levels of cobalt (Co) followed by nickel (Ni) in the white muscles (7.25 and 7.15.  $\mu$ g/g dry wt. respectively). Similarly, in gills Co was the highest followed by Ni (9.25 and 8.05  $\mu$ g/g dry wt. respectively). Copper has the highest level from liver of *Arius* sp. followed by nickel (10.65 and 8.40  $\mu$ g/g dry wt. respectively). However, in gonads of this species, both Ni and Co were high, but they were not significantly different (Table 1). The level of the investigated metals in gonads of this species can be arranged as follows: Ni>Co>Mn>Cu>Cd (9.50, 9.25, 6.05, 5.00 and 2.40  $\mu$ g/g dry wt. Total concentration of all heavy metals in both tissue

and organs can be ordered as follows: Liver> Gonads> Gills> white muscles. Nevertheless, the results obtained in this study were slightly higher than those obtained by Turkmen and Turkmen [23] and Shiva Kumar *et al.* [24] and lower than those reported by Abdullah and AbdulHassan [25]. The sum of all heavy metals in tissues and organs are provided in (Table 1).

The mean concentrations of the examined metals from *T. tanggol* are provided in (Table 2). It shows that from the white muscles (tissues) of this species both Ni and Co were high (7.95 and 7.80  $\mu$ g/g dry wt. respectively). The studied elements from the tissues of *T. tanggol* can be arranged in the following descending:

Table 1: Mean concentration ( $\mu\text{g/g}$  dry wt.) of heavy metals from white muscles and some organs (gills, liver, gonads) from *Arirus* sp. collected at Al-Hudaydah Red Sea coast of western Yemen

<i>Arirus</i> sp.	Ni	Co	Cu	Cd	Mn	Total(sum)
White Muscle	7.15	7.25	2.75	0.60	2.05	19.80
Gills	8.05	9.25	1.80	ND	3.65	22.75
Liver	8.40	7.65	10.65	1.60	6.30	34.60
Gonads	9.50	9.25	5.00	2.40	6.05	32.20
Total	33.10	33.40	20.20	16.60	18.05	109.35

Table 2: Mean concentration ( $\mu\text{g/g}$  dry wt.) of heavy metals from white muscles and some key organs (gills, liver, gonads) of *T. tanggol* collected at Al-Hudaydah, Red Sea coast of Western Yemen

<i>T. tanggol</i>	Ni	Co	Cu	Cd	Mn	Total (sum)
White Muscle	7.95	7.80	5.65	ND	1.75	23.15
Gills	7.75	13.50	3.90	ND	2.95	28.10
Liver	7.65	7.35	12.50	ND	3.80	31.30
Gonads	7.00	7.70	6.25	0.30	2.20	23.45
Total	30.35	36.35	28.30	0.30	10.70	106.00

Table 3: The mean concentration ( $\mu\text{g/g}$  dry wt.) of heavy metals from white muscles and some key organs (gills, liver, gonads) from *Mugil* sp. collected at Al-Hudaydah Red Sea Coast of Western Yemen

	Ni	Co	Cu	Cd	Mn	Total( sum)
White Muscle	6.55	6.25	2.65	ND	1.50	16.95
Gills	6.20	11.25	2.80	ND	5.30	25.55
Liver	6.85	7.30	8.10	2.90	5.80	30.95
Gonads	4.95	7.10	5.25	ND	2.45	22.75
Total	24.55	31.90	18.80	2.90	15.05	96.20

Ni>Co>Cu>Mn. The gills of this species have the highest mean concentration of Co (13.50  $\mu\text{g/g}$  dry wt). The liver of *T. tanggol* has the highest mean concentration of Cu (12.50  $\mu\text{g/g}$  dry wt.). The levels of the studied metals from liver of the same fish can be arranged as follows: Cu>Ni>Co>Mn. In the present study it was found that the mean concentration of copper from liver was much higher than the results obtained by ShivaKumar *et al.* [24] Bellassoud *et al.* [26] and lower than those reported by Abdullah and AbdulHassan [25] and Khalaf *et al.* [27]. Ni from our investigation also, was much higher than that reported by ShivaKumar *et al.* [24]. In addition to that the total concentration of all studied heavy metals and elements in tissues and organs from *T. tanggol* can be ordered as follows: liver> gills> gonads> white muscle and the sum of all are provided in (Table 2).

In the gonads of *T. tanggol* the levels of heavy metals from the investigated fish were greatly varied and can be ordered as follows: Co>Ni>Cu>Mn>Cd. The results obtained in this study are in agreement with those reported by Khalaf *et al.* [27]. There was no detection of Cd in tissues and organs of *T. tanggol* where the only exception was recorded in the gonads (0.30  $\mu\text{g/g}$  dry wt.). Also our results are in a good agreement with those

obtained by Khalaf *et al.* [27] and lower than what was reported by Abdullah and Abdul Hassan [25]. However, the sum of all heavy metals from the tissues and organs are provided in (Table 2).

Table 3 and Fig. 2 show the mean concentration of heavy metals in tissues and organs from *Mugil* sp. which reflects various concentrations of the studied elements in both tissues and organs where appreciable differences were observed between different organs of *Mugil* sp. In this species both Ni and Co were high in their concentration in white muscle (6.55 and 6.25  $\mu\text{g/g}$  dry wt.) respectively. Cobalt in the gills was the highest followed by Ni (11.25 and 6.20  $\mu\text{g/g}$  dry wt.) respectively. The mean total concentration of all the study heavy metals and elements in fish organs can be ordered as follows: liver>gonads>gills>white muscles. The levels of the investigated heavy metals and elements from the liver of *Mugil* sp. can also, be ordered as follows: Cu>Co>Ni>Mn>Cd. *Mugil* sp. The liver of this species have had the highest level of Cd. Cadmium concentration from the liver of *Mugil* sp. was lower than those reported by Khalaf *et al.* [27]. for the same organ. Results from gonads of *Mugil* sp. are also provided (Table 3) which shows that Co has the highest concentration followed by

Cu (7.10 and 5.25 µg/g dry wt. respectively with no detection of Cd in the gonads of *Mugil* sp. The results obtained here are in a good agreement with those reported by Khalaf *et al.* [27]. The sum of all heavy metals in the tissues and organs are provided in (Table 3).

#### Comparisons Between the Investigated Fish Species:

The accumulation of heavy metals in a tissue is mainly dependent upon their concentrations in water and the length of the exposure period. High levels of heavy metals were found from organs (liver, gills and gonads) when compared with white muscles (tissues). The obtained results in the present study are in agreement with the previous observations made by Deb and Fukushima [28], who reported that heavy metals may have high concentrations in gills, liver and gonads. These organs have relatively high potential for some metals accumulation such as copper (Cu), cadmium (Co), nickel (Ni) and Mn, [24]. The results have indicated the differences in sensitivity to the heavy metals among the fish species. The high concentration of cobalt, copper and nickel from tissues of the three fish species could be related to the essential role of these metals in the cellular and metabolic processes. The metals concentration in fish organs were much higher than those of non- essential metals such as Cd (even though low concentration of cadmium was detected ) however other research workers have proved that long term accumulation of this metal can cause damage to nerves, blood and the respiratory systems [29].

**White Muscles (Tissues):** In the present investigation Tables (1, 2&3) and Fig. 2 revealed heavy metals concentrations in tissues and organs of the examined fish species. It was found that the fish tissues have had the lowest levels of all the study elements, when compared to other fish organs. The levels of heavy metals in tissues were arranged between 0.6-7.25, 1.75-7.95 and 1.50 -6.55 µg/g dry wt. for *Arius* sp., *T. tanggol* and *Mugil* sp. respectively.

Although, the results obtained from the present investigation are in agreement with those reported by Turkmen and Turkmen [23] and Khalaf *et al.* [27], but they can be considered higher than those already reported by Heba *et al.* [7] and Abdelmoneim *et al.* [30].

#### Comparisons Between Different Fish Organs:

Table (1, 2, &3) and Fig. 2 show the mean concentrations of the studied heavy metals from organs of the fish species under this investigation (*Arius* sp. *T. tanggol* and

*Mugil* sp.). Generally, the investigated fish revealed high level of Co, Cu, from gills and livers and high level of Ni and Co from gonads of *Arius* sp. only (Fig. 2). The results obtained here regarding the levels of Cu and Cd are in agreement with those reported by Abdelmoneim *et al.* [30], who found that both Cu and Cd recorded their highest values from *Saurida* sp. Although, in this study it was obvious that all fish tissues and organs show the lowest level of Cd, however, the exception were noticed only from livers of *Mugil* sp. and gonads of *Arius* sp. and the concentrations were 2.9 and 2.40 µg/g dry wt. respectively (Table 1 & 3).

The livers of *Arius* sp. have had the highest level of Cu followed by Co from gills, where the metal concentrations were 10.65 and 9.25 µg/g dry wt. respectively. In the gonads of the same species, both Ni and Co were high and there are no significant differences between levels of these two elements. However, levels of metals obtained from this study were lower than those reported by Khalaf *et al.* [27] and higher than the results recorded by Abdelmoneim *et al.* [30] and Kalyoncu *et al.* [31]. It was observed that in *T. tanggol* Co and Cu were the highest (13.5 and 12.50 µg/g dry wt.) in both gills and livers respectively.

Similarly Table 3 and Fig. 2 revealed that *Mugil* sp. have had the highest levels of both Co and Cu (11.25 and 8.10 µg/g dry wt.) as shown from its gills and livers respectively. Nevertheless, in the following sections the concentrations of each of the studied elements in both tissues and organs of the examined three fish species will be discussed separately.

**Nickel (Ni):** Tables (1, 2 & 3) and Fig.2 show acceptable variations in the levels of the studied elements found from the three fish species under this investigation. Also, it was found that in tissues of the studied fish the levels of Ni ranged between 6.55-7.95 µg/g dry wt. Ni levels in the white muscles were: 7.15, 7.95 and 6.55 µg/g dry wt. for *Arius* sp., *T. tanggol* and the *Mugil* sp. respectively. Among fish species *T. tanggol* have the highest level of Ni (7.95 µg/g dry wt.). It was observed that levels of Ni from the present study were higher than those reported by Heba *et al.* [7] and Khalaf *et al.* [27] and Heba and Al-Mudaffer [32].

**Cobalt (Co):** Similarly the concentrations of Co from the white muscles are shown in Tables (1, 2 &3) and Fig. 2. The levels of Co from the tissues of examined fish ranged between 6.25-7.80 µg/g dry wt. The highest level was found from *T. tanggol* followed by *Arius* sp., with relatively high

mean concentrations of Cu and Co found from livers and gills of the investigated animals (Fig. 2). In the present study it was found that the levels of Co from the tissues were much higher than those reported by Ates *et al.* [33] and were four fold than the results found by Kalyoncu *et al.* [31].

**Copper (Cu):** Tables (1, 2 & 3) and Fig. (2) showed relatively high mean concentration of Cu obtained from gills and livers of the examined fish. It was found high in livers of *T. tanggol* followed by *Arius* sp. (12.50 and 10.65  $\mu\text{g/g}$  dry wt.). The levels of Cu in the examined fish tissues and organs ranged between 2.65 and 12.50  $\mu\text{g/g}$  dry wt. There was variation in Cu content from the livers among species under this investigation, which ranged between 8.10 and 12.50  $\mu\text{g/g}$  dry wt. for *Mugil* sp. and *T. tanggol* respectively. Nevertheless, our findings were much higher than those reported recently by Ates *et al.* [33] for white muscles. The heavy metals levels from the organs of the studied fish are in a good agreement with those recorded by Abdullah and Abdul Hassan [25].

**Cadmium (Cd):** Cadmium (Cd) has not been found to occur naturally in its pure state and its concentration seems to be directly proportional to zinc and lead. The use of cadmium in agriculture and industry has been identified as a major source of wide dispersion into the environment and food. Many chemical elements that are present in aquatic food are essential for human life at low concentrations, but it can be toxic at high levels (concentrations), while others such as mercury (Hg), cadmium (Cd) and lead (Pb) were not known to be performing essential functions in life and are toxic even at low concentrations when ingested over a long period of time.

Cadmium is accumulated primarily in the major organs of fish rather than in muscles [34]. When cadmium is detected usually occurred at fairly low levels and within SASO limits in the muscle tissues of fish. Although, the level of Cd in the edible parts of fish muscles showed values within SASO's recommended maximum limit of 0.5mg/kg, its level from gills, livers and gonads slightly exceeded this limits. In general, it can be stated that the levels of Cd found in the edible parts of the three fish species from the present study are still considered as those of uncontaminated fish (<1.5).

Cadmium in the present study was found only in the white muscles of *Arius* sp. (0.6  $\mu\text{g/g}$  dry wt.) (Table 1 and Fig. 2). The levels of Cd obtained in the present investigation were slightly higher than the results

reported by Ates *et al.* [33] and were much lower than those found by Al-Tae [35]. Cd was relatively low from tissues, when compared to the other remaining organs. However higher concentration means of Cd were recovered from livers, gills and gonads which ranged between 0.30–2.90  $\mu\text{g/g}$  dry wt. (Tables 1, 2, 3 and Fig. 2).

**Manganese (Mn):** The mean concentrations of Mn in tissues from the examined fish species are also shown in (Tables 1, 2 & 3 and Fig. 2). It ranged between 1.500-2.05  $\mu\text{g/g}$  dry wt. for tissues. Mn levels found from organs were higher than those found in tissues of the examined fish (Fig. 2). However, the levels of Mn obtained from this study were lower than those recorded by Kalyoncu *et al.* [31] and higher than those reported by [32, 36]. Because most trace metals tend to accumulate in the different body organs, these metals are dangerous for fish and in turn they lead to serious problems in both humans and animals. Normally fish absorb dissolved heavy metals and trace elements from their feeding diets and the surrounding waters leading to their accumulation in various tissues in significant amounts which might be evidently exhibiting and eliciting toxicological effects in their targeted organs at their best criteria [37].

Tables (1, 2 & 3 and Fig. 2) show the results from the present study which indicated significant difference between tissues and organs of the studied fish. It also shows an appreciable variation in the concentration of the study elements. In addition to that it reflects different fish organs having different concentration of the studied elements. It was noticed that the concentrations of the investigated elements were much higher from fish organ than their white muscles of the same animals (Tables 1- 3 and Fig. 2).

Therefore when comparing our data with the literatures (Tables 4 & 5), it is clearly evident that the three fish species under this investigation have high concentration of metals (Ni, Co and Cu) in their white muscles with undetected or low concentration of the cadmium and comparable results for Mn (Table 4).

Also, high concentrations of Ni, Co and Mn were noticed with comparable results for Cu and Cd for other fish organs including gills, liver and gonads (Table 5) which also showed high concentration of Ni, Co and Mn with comparable results for Cu and cadmium for other fish organs including gills, liver and gonads. Regarding the arrangement of heavy metals concentration in organs of each species depending on the accumulation of metals could be reported as follows: in case of the organs of the

Table 4: Mean concentration ( $\mu\text{g/g}$  dry wt.) of heavy metal from fish white muscles compiled from different studies and from the present investigation at Al-Hudaydah coastal area at the Red Sea coast of Western Yemen

Regions /Species	Ni	Cd	Co	Cu	Pb	Zn	Ag	Mo	Li	Mn	References
Polluted regions	7.80	0.92	0.00	0.00	20.1	517.8	0.00	0.00	0.00	3.90	[38]
World wide	1.00	0.10	0.20	-	3.00	80.00	0.00	0.00	0.00	10.00	[39]
<i>Gnathanodon speciosus</i>	1.19	2.57	0.00	1.77	1.60	43.36	0.00	0.00	0.00	0.34	[32]
<i>Chorynemus lysan</i>	1.60	2.65	1.58	2.20	2.10	81.03	0.00	0.00	0.00	1.24	[40]
<i>Pomadsys opercularis</i>	1.98	2.80	1.08	2.96	3.80	52.18	0.00	0.00	0.00	3.16	[40]
<i>E. tauvina</i>	0.05	0.50	0.10	0.00	0.10	7.90	0.05	2.35	0.10	0.50	[7]
<i>Decapterus macarellus</i>	2.48	0.35	0.00	2.56	1.31	114.3	0.00	0.00	0.00	0.00	[27]
<i>Decapterus macarosoma</i>	1.09	1.26	0.00	6.11	1.12	20.30	0.00	0.00	0.00	0.00	[27]
<i>Decapterus russelli</i>	0.66	1.02	.000	4.36	1.06	23.60	.000	.000	.000	.000	[27]
<i>Cat fish</i>	0.05	0.04	.000	1.69	5.14	7.67	.000	.000	.000	5.14	[22]
<i>Tilapia</i>	0.02	0.00	0.00	1.50	0.75	6.50	.000	.000	.000	1.09	[22]
<i>Arius</i> sp.	7.15	0.6	7.25	2.75	0.00	0.00	0.00	0.00	0.00	2.05	Present study
<i>T. tanggol</i>	7.95	0.00	7.80	5.65	0.00	0.00	0.00	0.00	0.00	1.75	Present study
<i>Mugil</i> sp.	6.55	0.00	6.25	2.65	0.00	0.00	0.00	0.00	0.00	1.50	Present study

Table 5: Mean concentration ( $\mu\text{g/g}$  dry wt.) of heavy metals in fish organs (gill, liver and gonads) compiled from different studies and from the present investigation at coastal area at the Red Sea coast western of Yemen

Fish sp.	Organs	Ni	Co	Cu	Cd	Mn	References
<i>Sardinella gibosa</i>	gill			0.51	0.72		[30]
	liver			2.55	0.62		
	gonads			1.97	0.40		
<i>Epinephelus</i> sp.	gill			1.20	1.05		[30]
	liver			9.60	1.17		
	gonads			3.65	0.80		
<i>Decappterus macarellus</i>	gill	9.81		3.87	0.16		[27]
	liver	1.66		19.73	8.38		
	gonads	2.79		3.31	0.25		
<i>Decappterus macarosoma</i>	gill	9.58		5.15			[27]
	liver	1.09		11.00	1.17		
	Gonads	1.25		3.00	1.17		
<i>Decappterus ruselli</i>	Gill	0.69		5.98	1.08		[27]
	Liver	0.45		11.90	2.35		
	Gonad	0.44		5.21	2.05		
	liver			47	4.2		
<i>Oreochromis aureus</i>	gill			9.32	0.24		[41]
<i>Arius</i> sp.	gill	8.05	9.25	1.80	ND	3.65	Present study
	liver	8.40	7.65	10.65	1.60	6.30	Present study
	gonads	9.50	9.25	5.00	2.40	6.05	Present study
<i>T. tanggol</i>	gill	7.75	13.50	3.90	ND	2.95	Present study
	liver	7.65	7.35	12.50	ND	3.80	Present study
	gonads	7.00	7.70	6.25	0.30	2.20	Present study
<i>Mugil</i> sp.	gill	6.20	11.25	2.80	ND	5.30	Present study
	liver	6.85	7.30	8.10	2.90	5.80	Present study
	gonads	4.95	7.10	5.25	ND	2.45	Present study

*Arius* sp. the investigated organs can be arranged in a descending order as follows: liver>gonads> gills> white muscles, whereas in *T. tanggol* sp. the ordering of the same elements can be arranged as follows: liver>gills> gonads> white muscles. Similarly the study organs from the *Mugil* sp. can be arranged as follows: liver>gonads>gills>white muscles. Finally it was noticed

that all the studied three fish species revealed high levels of heavy metals from livers and low levels from the white muscles.

No doubt that the liver organs are well known as essential organs in the fish life but unfortunately are described as organs dubbed with high accumulation of heavy metals. On the other hand the white muscles were



evidently the lowest heavy metals accumulated tissues of the investigated three fish species. This is mainly important because the fish muscles contribute the major mass of flesh that is consumed by humans as food.

## CONCLUSION

In conclusion, the main reasons why some metals are high in our studied fish species may be due to the anthropogenic activities in the study area, the higher lipid content of fish (*Arius* sp.) and the preferential differences in their diet uptake.

Naturally, the higher level of the marine life affinities for some metals to accumulate in some fish, the higher level of some heavy metals and trace elements in the sediments and food chain and in the case of this study coupled with the proximity of the study area to the effluent of sewage, power plant. This study recommended more critical studies should be conducted to give more detailed insights about the current situation of heavy metals in the overall fish fauna.

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