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Determination of Iron in some Fish Species from the Red Sea, Duba Coast, Tabuk, Saudi Arabia

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Abstract: **The current study aimed to determine the accumulated levels of iron (Fe) in nine fish (*Lethrinus nebulosus, Hipposcarus harid, Aphareus rutilans, Siganus rivulatus, Dicentrarchus labrax, Sparus aurata, Argyrops spinifer, Epinephelus tauvina* and *Sargocentron spiniferum*) organs (muscle, heart, gills and liver) collected from Duba, Northern Red Sea coast, Saudi Arabia. (Febrauary and March 2019). Fish species and their tissues showed different values for accumulating iron, *Hipposcarus harid* had the highest iron value and the lowest value was obtained from *Siganus rivulatus.* The lowest values of accumulated Fe were recorded in the muscle, while the highest values recorded in the liver in nine fish species. Considering all studied fish species and tissues, the average Fe concentrations occurred in the ranges between 2.5– 25.9 (µg/g wet weight). Generally, Fe concentration (µg/g ww) from the examined fish species followed an abundance of: *Hipposcarus harid > Sparus aurata>Lethrinus nebulosus> Sargocentron spiniferum >Aphareus rutilans>Argyrops spinifer>Dicentrarchus labrax> Epinephelus tauvina >Siganus rivulatus.* However, Fe concentrations in fish species tissues followed an abundance of: liver >heart>gills>muscles. Generally, the values of Fe in the fish muscles were accepted by the international legislation limits and are safe for human consumption.**

Keywords: **Heavy metals. iron, Fish, Duba Coast, Red Sea, Saudi Arabia.**

1. INTRODUCTION

Today, there are increasing in the world's growing demand for fish. fish serve as a major source of protein, essential fats (omega-3 fatty acids), vitamin D, calcium, B vitamins, vitamin A, iron, zinc, and lysine for hundreds of millions of people, and are an important part of a healthy diet (Thilsted et al., 1997; Roos et al., 2007; Youn et al., 2014), and more than 250 million people depend on fish as a source of livelihood (FAO, 2014). Besides the food and income benefits provided by fish can afford opportunities labor (Welcomme et al., 2010; Kennedy et al., 2003).

Consumption of fish has been shown to mitigate the effects of some micronutrient deficiency-related illnesses, such as rickets in children (Craviari et al., 2008). Moreover, fishes can be readily dried or preserved, they also provide year-long nutrient sources (Musumali et al., 2009). Besides fish also serve as environmental indicators for water pollution, where,fish respond directly to some environmental stressors such as toxic and thermal pollution and climate change (Dudgeon et al., 2006). Fish also respond indirectly to stressors that impact their environment. For example, the massive die-offs of alewives in USA brought to public and political attention large ecological changes occurring in the water (Ludsin et al., 2001). Finaly, overfishing, ineffective management practices, industrial development and pollution have reduced fish stocks.

Fishes respond to many changes in the aquatic environment, making them valuable bioindicators of ecosystem health. The Index of biotic integrity (IBI) is a commonly used in-situ assessment tool for freshwaters based on the local fish assemblages (Karr, 1981). Due to their representative susceptibility to many chemicals and key role in aquatic ecosystems, fish species are also commonly used as laboratory models to assess water quality and environmental toxicology in the chemical and pesticide approval processes (Barbour et al., 1999).

Fish can be considered part of the “green food” movement for more environmentally friendly sourcing of food. Sustainable harvest of fish can have relatively few environmental costs, especially when compared with replacement livestock products (Orr et al., 2012). fisheries have low environmental costs compared with many alternative animal-derived food sources.

Environmental pollution by heavy metals is considered as one of the most serious problems in the world over the last few decades. Emissions of heavy metals to the environment occur via a wide range of pathways, including air, water and soil, threatening the animal and human health and quality of the environment (Järup, 2003; DekoFehinti et al., 2012).

Contamination with heavymetals is a serious threat because of their toxicity (Eisler, 1988). Heavy metal toxicity could be present in different ways depending on its route of ingestion, its chemical form, dose, tissue affinity, age and sex, as well as whether exposure is acute or chronic.

The main source of heavy metals in fish arises from contamination of fish feed and water (Johri et al., 2010). Other sources of contamination can by industrial wastes and mining can create a potential source of heavy metal pollution in the aquatic environment (Gumgum et al., 1994; Lee and Stuebing, 1990). The effects of heavy metals are partly due to the direct inhibition of enzymatic systems and also to the indirect alteration of the essential metal ion equilibrium. Majority of the known metals are very toxic to living organisms and even those considered as essential can be toxic if present in excess (Celik and Oehlenschlager, 2007).

Iron is an essential element in the cellular respiration process through its oxidation-reduction activity and electron transfer. It is found in the body mainly in the complex form bound to proteins and enzymes. Fish can absorbs soluble iron from the water through the gills. Iron was absorbed from the peritioneal cavity and stroed in the liver, spleen and anterior kidney (National Research Council, 1993).

Maximum acceptable concentration from iron (300 μg/L) = (0.3 ppm), water becomes contaminated when iron concentration is 300-1000 (μg/L) = (0.3 – 1 ppm). If the iron concentration is greater than 1ooo (μg/L), the water is not valid, means iron concentration has reached toxicity (Ritter et al., 2002; US-EPA, 2002; WHO, 2011).

Iron defeciency causes anemia and the normal liver color changed to yellow-white during iron deficiency. Iron toxicity signs develop in fish when more than 1ooo ppm. The major effects of iron toxicity include reduced growth, increased mortality, diarrhea and histopathological damage to liver cells.

Considering the fact that fish and its products can contain some toxic heavy metals and therefore exposure to the toxic trace metals will be gained through consumption of these products, therefore, the accurate determination of heavy metals has been focused by researchers in last decades, worldwide (Alturiqi and Albedair, 2012; Bat et al., 2014; FAO 2014; Shaltout et al., 2018) in order to check for those hazardous to human health (Farkas et al., 2003; Mansour and Sidky, 2002; Moiseenko and Kudryavtseva, 2001). Heavy metals transfer to animals and humans through the food chain (Abou-Arab, 2001; Demirezen and Aksoy, 2004).

Therefore, the aim of this study was the assessment of Fe concentrations in edible fish species consumed in Saudi Arabia.

2. MATERIALS AND METHODS

Study area and sampling locations

Duba is a small city on the northern Red Sea coast of Saudi Arabia (Figure1), it is in Tabuk Province. Local citizens describe it as The Pearl of the Red Sea. The population of Duba is about 22,000. Duba is located in the northwest of Saudi Arabia on the coast of the Red Sea. Duba includes 3 valleys, Dahkan to the north, and Salma and Kafafah on the south. Duba is a port city and ferries and ships operate from Saudi Arabia for Egypt and Jordan. The Hurghada and Safaga ports of Egypt can be reached within about 3 hours (minimum) by ferry. It is about 180 km from Tabuk (180 km) and there are notable beaches such as Sharma beach.

Fig. 1. Map of Duba, Tabuk, Saudi Arabia

Collection, preparation and digestion of the samples

The present study was carried out during February and March, 2019. Nine consumed fish species [Spangled emperor (*Lethrinus nebulosus*), Candelamoa parrotfish (*Hipposcarus harid*), Rusty jobfish (*Aphareus rutilans*), Marbled spinefoot (*Siganus rivulatus*), European seabass (*Dicentrarchus labrax*), Gilthead seabream (*Sparus aurata*), King soldier bream (*Argyrops spinifer*), Greasy grouper (*Epinephelus tauvina*) and Sabre squirrelfish (*Sargocentron spiniferum*)] with their mean weight (428, 80, 510.5, 215, 188.5, 412, 188, 433.5 and 622 g, respectively) and their mean length (28.5, 28, 29, 29, 22, 28.5, 18, 29 and 35 cm, respectively) were collected from the port of Duba, Tabuk, Kingdom of Saudi Arabia (Figure 2). Immediately after the collection, all samples were kept in clean polythene bags inside an airtight insulating box and thereafter transported to the biology department laboratory, faculity of Science, Tabuk University, Saudi Arabia. The samples were rinsed with deionised water to remove surface adherents at the laboratory. The fish were then dissected and the intestines were extracted by longitudinal incision and the liver, heart and gills were separated. The edible part (muscles) of the fish samples, heart, liver and gills were weighed and cut into small pieces using clean scissors and knife in sterile glass bottles. Constant weight is obtained, a portion of 0.5 g samples was transferred directly to the digestion vessels that were soaked in HNO_3 for 24 h, according to (AOAC, 1995; Baki et al., 2018; Tiimub and Afua, 2013). The digested samples were filtered using Whatman no. 42 filter paper and the filtrate was diluted to 50 mL with deionised water (Figures 3 and4). Atomic absorption spectrophotometer was used to determine Fe.

Fig.2. Showing the all samples

Fig.3. Showing the fish dissected in the lab.

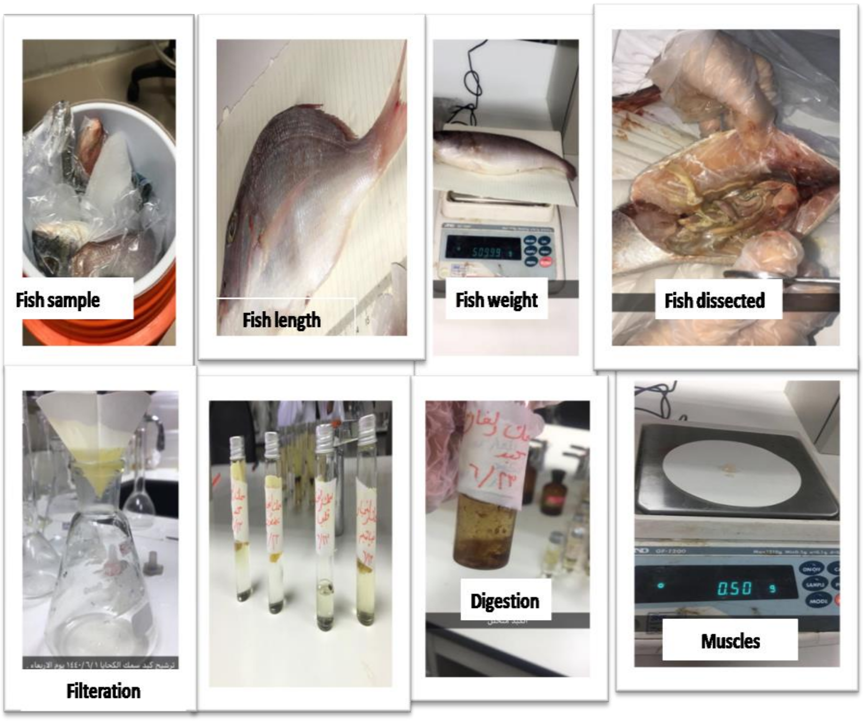

Fig. 4. Showing preparing, dissected and separated the muscles, heart, liver and gills of the fish samples and digestion

Statistical Analysis

Analysis of Variance (ANOVA) test was applied for statistical evaluation of the obtained results of Fe detected in the examined samples of fish organs according to Blair (1981) and Montgomery (2001).

3. RESULTS

The mean concentration of Fe (µg/L) in surface water of Duba coast was detected during Febrauary and March 2019. It was found that the concentration of iron (238.0 µg/L) in the water sample within the permissible limits did not exceed. Where the permissible limits (PL) in Sea water according to guidelines in (US- EPA, 2002, WHO, 2011) was .(300.00 µg/L). Our result has been compatible with (El-Sayed et al., 2004; Al-Wesabi et al., 2015).

The results of this study show the concentration of heavy metal (Fe) in nine species of fish [Spangled emperor (*Lethrinus nebulosus*), Candelamoa parrotfish (*Hipposcarus harid*), Rusty jobfish (*Aphareus rutilans*), Marbled spinefoot (*Siganus rivulatus*), European seabass (*Dicentrarchus labrax*), Gilthead seabream (*Sparus aurata*), King soldier bream (*Argyrops spinifer*), Greasy grouper (*Epinephelus tauvina*) and Sabre squirrelfish (*Sargocentron spiniferum*)] collected from the Duba Coast, Duba, Tabuk, Kingdom of Saudi Arabia in 2019.

The results of this study were illustrated in figures (5-7). In respect of Fe concentration (µg/g ww) in examined fish can be arranged as follows: *Hipposcarus harid* > *Sparus aurata*>*Lethrinus nebulosus*> *Sargocentron spiniferum* >*Aphareus rutilans*>*Argyrops spinifer*>*Dicentrarchus labrax*> *Epinephelus tauvina* >*Siganus rivulatus*. In another meaning, *Hipposcarus harid* was the highest mean concentration of Fe (16.75) followed by *Sparus aurata* (16.23), *Lethrinus nebulosus* (15.05), *Sargocentron spiniferum* (14.9) and then *Aphareus rutilans* (11.5), *Argyrops spinifer* (11.4) *Dicentrarchus labrax* (10.75), *Epinephelus tauvina* (10.65) and finally *Siganus rivulatus* which gave the lowest mean Fe concentration (10) (Figure 5).

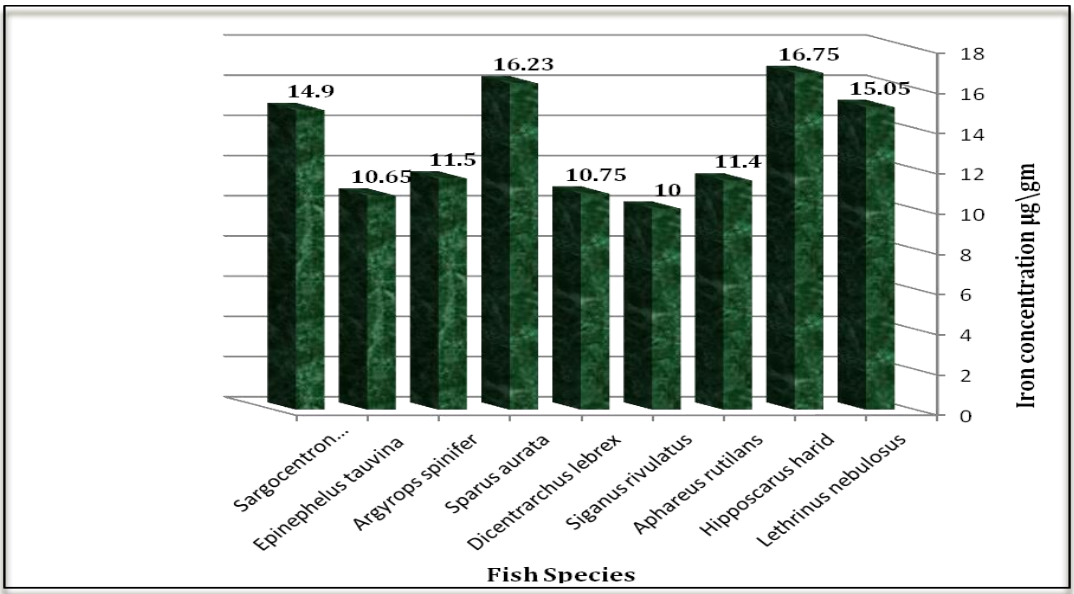

Fig.5. Mean content of iron in nine fish samples

Considering fish organs, the concentration of Fe (µg/g ww) ranged within: liver (21.32), heart (15), gills (11.26) and muscles (4.52). We can arrange fish organs according to the content of iron as follows: liver>herat>gills>muscles. In the present study, the highest amounts of the examined Fe were observed in the liver fowlloed by herat, gills, and muscles which gave the lowest mean Fe concentration (Figure 6). Our results corresponds to the results obtained by Uysal et al. (2008). The results indicate that the concentrations of Fe in all fish organs were significantly higher than that in the muscles ($p<0.05$). This is confirmed in many other studies (Allen-Gil and Martynov, 1995; Bervoets et al., 2001; Liang et al., 1999). Liang et al. (1999) demonstrated that higher metal content in viscera was related to their important role in trace metal storage in fish. Many authors (Sobhanardakani et al., 2011; Szarek-Gwiazda and Amirowicz, 2006; Bervoets et al., 2001) analyzed metal content mainly in such organs of fish, as liver, gills and muscles. They reported the highest accumulation in the liver,kidneys, or gills. Our results are in concordance with authors mentioned above. Szarek-Gwiazda and Amirowicz (2006) pointed on the liveras storage organs for Fe. According to Morsy and Protasowicki (1990), heavy metals are supposed to be bound by the surface of gills, which affects proper functioning of the organ. Ptashynski et al. (2002) indicated that metal absorption in fish is carried out via two uptake routes: digestive tract (dietary exposure) and gill surface (waterborne exposure). the most important road of entering Fe is taken up by the digestive system, skin, and gills of fish.

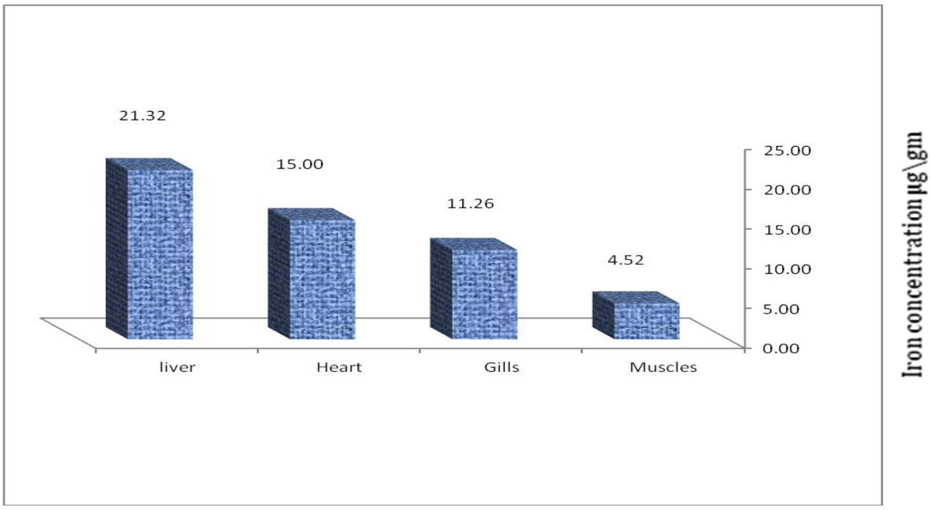

Fig.6. Mean content of iron in different organs samples

Figure 7 show that there were significant differences at the 0.05 level between all the different fish organs (liver, heart, gills and muscles) in their iron content in all fish samples under study.

Liver organ was superior in iron content than the rest of organs followed by heart, gills and then muscles had the lowest iron content. The content of iron in liver of all samples varies from 17.4 to 25.9 (µg/g ww).

Sparus aurata showed significantly higher iron content in liver, gills and muscles and *Hipposcarus harid* had the higher iron content in heart than the rest of all fish samples.

While *Hipposcarus harid* had the second higher iron content in liver, gills and muscles and *Lethrinus nebulosus* had the second higher iron content in heart than the rest of all fish samples. On the meantime, *Sargocentron spiniferum* has the third higher iron content in liver and heart. *Epinephelus tauvina* had the third higher iron content in gills and *Aphareus rutilans* had the third higher iron content in muscles. On the other hand, *Sargocentron spiniferum* had the fourth higher iron content in gills and muscles and *Sparus aurata* had the fourth higher iron content in heart and *Lethrinus nebulosus* had the fourth higher iron content in liver. Other fish samples had lower essential iron content. *Dicentrarchus labrax* and *Argyrops spinifer* had lower iron content Finally, *Siganus rivulatus* was the least iron content in liver and gills, and *Aphareus rutilans* was the lowest iron content in heart and the lowest muscles iron content was *Epinephelus tauvina* (Fig. 7).

The results of the study showed that the concentration of iron ranged between 2.5- 25.9 (µg/L) in fish samples. Where the permissible limits (PL) in fish musles µg/g wet wt.) according to (WHO guidelines, 1989; Mokhtar, 2009) was.(100.00 µg/g wet wt average daily intake in wet wt). Our result has been compatible with (El-Batrawy et al., 2018).

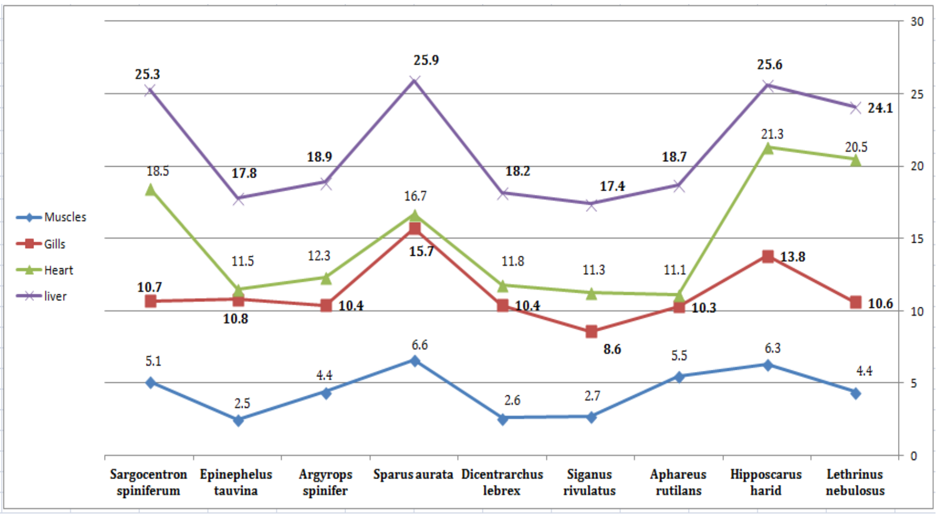

Fig.7. Iron (Fe) concentration (µg/g wet wt.) in nine fish samples

4. DISCUSSION

Heavy metals residues in foods of animal origin such as fish and other protein sources is a serious issue and need a great concern because these metals are highly toxic in nature and had adverse effects on human health (Umer et al.,2017).

The results of the present study revealed that the level of Fe in the (muscle, liver and gills) of tested fish tended to vary from species to another. The variation may be due to different in the fish activity, fish habitat and the influence of the surrounding ecosystem statues, metabolism rates, feeding habitats, ecological needs, and physiologically (Authman and Abbas, 2007). However, Fe concentration can vary because of certain biological conditions, such as species, sex, age, and feeding, chemical form, as well as whether exposure is acute or chronic (Håkanson, 1984; Protasowicki, 1986; Johri et al., 2010).

The highest concentrations of Fe were recorded in the liver while lowest concentration was recorded in muscle. Various reasons may be attributed to the lower accumulation of Fe in the muscle: 1) the muscles does not come into direct contact with toxicant medium as it is totally covered by the skin. The presence mucous layer coating fish skin surface served as a barrier which protects the integrity of fish muscle tissue from surrounding contaminants. The mucous layer serves as the first line of defence against the entrance of heavy metals into fish flesh by forming complexes with the heavy metals and this in turn make the fish muscle tends to accumulate less concentration of metals compared with other fish organs as reported by (Uysal, 2008). 2) The muscle is not an active site for detoxification (Jagakumar and Paul, 2006). Therefore, transport of heavy metals from other tissue to muscle does not occur.

On the other hand, our results showed that highest concentration of Fe were accumulated in the liver of all fish species. This may be due to the fact that the liver in fish as in other vertebrates is the major site for biotransformation and detoxification of different kinds of xenobiotic. Liver is the first sensitive organ for metal accumulation, since the accumulation of heavy metals not only depended on the structure of organs but also depended on interaction between metals and the target organs (Sorensen, 1991). Metals induced metallothionine content in tissues which has been mostly affective in the liver.

The present study showed that Iron (Fe) recorded the highest concentrations in the liver, heart, gill and muscle of studied fish, its concentrations were loeer than the maximum permissible level for Fe. Adeyeye (1993) found that the high accumulation of Fe in fish may be attributed to large quantities in water. Fe depending on the form of existence ion reacts directly with water to produce ferric hydroxide which makes the water body deficient in oxygen as results of its acidic characteristics there by creating anaerobic condition resulting to death of fish.

Previous studies show that water is an iron source that penetrated into fish through the gills. Salánki et al. (1982) reported that there are relation between Fe levels detected in fish organs samples seem to reflect the pollution level of the sediment and water. In such conditions, according to previous studies (Farkas et al., 2002), the metal uptake from food is predominant. Fe concentrations in water and in the muscles.

5. CONCLUSIONS

Duba coast has received a great attention because of its environmental and economic importance for being a significant source of fish production in Saudi Arabia. The study was designed to evaluate Fe metal pollution in Duba coast. The values of heavy metal (Fe) were measured in Duba coast water, muscles as well as (heart, liver and gills) of nine fish (Lethrinus nebulosus, Hipposcarus harid, Aphareus rutilans, Siganus rivulatus, Dicentrarchus labrax, Sparus aurata, Argyrops spinifer, Epinephelus tauvina and Sargocentron spiniferum) during February and March 2019. In the present study, the obtained values of Fe in water sample was (238.0 μg/L). The liver followed by heart and gills have higher concentrations of Fe than muscles. The order of fish samples according to their Fe conentration was *Hipposcarus harid > Sparus aurata>Lethrinus nebulosus> Sargocentron spiniferum >Aphareus rutilans>Argyrops spinifer>Dicentrarchus labrax> Epinephelus tauvina >Siganus rivulatus.*

There were significant differences on metal concentrations in organs of fish between the same species and between the others. It was found that the liver in *Sparus aurata* had the highest concentration of Fe (25.9 μg/g wet wt.) and liver in *Siganus rivulatus* had the lowest concentration of Fe (17.4 μg/g wet wt.). Heart in *Hipposcarus harid* had the highest concentration of Fe (21.3 μg/g wet wt.), and heart in *Epinephelus tauvina* had the lowest concentration of Fe (10.8 μg/g wet wt.). Gills in *Sparus aurata* had the highest concentration of Fe (15.7 μg/g wet wt.), and *Siganus rivulatus* had the lowest concentration of Fe (8.6 μg/g wet wt.). Muscles in *Sparus aurata* had the highest concentration of Fe (6.6 μg/g wet wt.), and *Epinephelus tauvina* had the lowest concentration of Fe (2.5 μg/g wet wt.). Health risk analysis of heavy metal (Fe) in the edible parts of the fish indicated safe concentrations for human consumption, and values in the muscles are generally accepted by the international legislation limits. The concentrations of metals in water and fish studied should be continuously monitored to keep it safe, as well as the wastewater must be treated before being drained into the water. In addition, cooperation between different authorities and efforts are needed to protect the biodiversity in Duba coast.

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