# Determination and comparisons of heavy metals (Cobalt and Iron) accumulation in muscle, liver, and gill tissues of Golden Mullet (*Chelon aurata*) in coastal areas of the Caspian Sea (Mazandaran and Golestan provinces of Iran)

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**Abstract**

The present research has aimed to figure out the amount of two heavy metals (Cobalt and Iron) accumulation, in muscle, liver, and gill tissues of *Chelon aurata* (golden mullet) in coastal districts of the Caspian Sea in two provinces of Iran and compare these data with their standard levels that advertised by some health organizations. It is because this species currently has the second-highest percentage of catch in the Iranian coastal of the Caspian Sea.

Sampling mature *Chelon aurata* (*C. aurata*) was done in 6 stations of beach areas and 30 mature *Chelon aurata* were chosen to run the study. The biometric results illustrated that the highest recorded data of average body weight (BW), body length (BL), and fork length (FL) were related to gulden mullet which were caught at the coastal district of Behshahr station, however, the golden mullet fish caught at Gomishan beach had the lowest recorded figures of body weight ($p$<0.05). The most amount of accumulation of Cobalt and Iron was recorded in Behshahr which showed a statistically significant difference with the other stands ($p$<0.05). The liver, gill, and muscle samples had the most Cobalt and Iron accumulation, respectively (Liver>Gill>Muscle). According to the recorded data at present research, the accumulation balances of two heavy metals, Cobalt and Iron, were much lower than their announced standard ranges of World Health Organization (WHO), Food and Agricultural Organization (FAO), and United States Department of Agriculture (USDA). It is therefore recommended that utilization of this kind of fish which has grown under that environment is useless for human consumption.

**Keywords:** Iron, Cobalt, *Chelon aurata*, Tissues, Caspian Sea, Iran

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## Introduction

Food is one of the most important factors for human and animal growth and survival so that there is no food which can alone guarantee and support the health of people which can support most of the nutritional requirements but seafood is a complete diet for human consumption that can supply most of the requirements of a human body and fish is one of the seafood which can cover most of the nutritional requisites. In general, aquatic animals, due to their compositions, especially the presence of valuable omega-3 fatty acids are known as healthy foods (Venugopal and Shahidi, 1996). According to the FAO data in 2020, during the last 50 years ago, global fish consumption enhanced around 3.1% per year; a couple of times more than inhabitants gain at the similar terms (FAO, 2020a,b). The statistics illustrated that only fish consumption has remarkably grown from 5.2 kg per individual in 1961 to 19.4 kg in 2017 (FAO, 2020a). The consumption of seafood is increasing around the world but utilization of them in Iran per capita is completely lower than the average of standard human consumption per capita. It is, therefore requires more researches, planning, and advertising about the nutritional values of aquatic animals (FAO, 2008).

Nowadays, raising awareness of the importance of nutrition for protecting consumer health is decisive to choosing the food of high nutritional value (www.fao.org/fishery). In terms of nutritional value, protein, lipid, carbohydrate, fiber, and ash are some of the components of the fish fillet which are the most important nutritional foodstuffs.

The high dispersion of heavy metals on the ground, their various uses, and especially the toxic properties of these heavy metals, have caused this group of metals to become one of the most important environmental pollutants. On the other hand, industrial waste, geochemical structure and, mining of metals are the potential sources of heavy metal contamination in the aquatic environment (Friedrich and Stepanowska, 1999). These heavy metals are divided into two classes, transition metals and, metalloids. Transition metals (Zinc, Copper, Cobalt, Iron and, Manganese) contain essential elements in low concentrations for the metabolic (biological) activities of the body so that they play as a toxic metal in high density whereas, metalloids (Arsenic, Cadmium, Lead, and Mercury) are not usually required for biological activities of the human body and they are toxic in low concentrations.

These heavy metals in aquatic organisms and marine organisms may be toxic in either an accessible metabolic form or gradually accumulate in different aquatic organs. The rate of absorption and accumulation of heavy elements in aquatic animals, and in particular fish, is dependent on ecological, physical, chemical and, biological conditions of the water, elemental species, aquatic and physiological conditions of the body in



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different regions of the Caspian Sea (Elsagh and Rabani, 2010).

*Characteristics of Cobalt heavy metal*

Cobalt exists in nature in the various chemical compound formations. Pure cobalt is a shiny, hard and, grey metal and Cobalt plays a major role in metabolic activities at low concentrations, also it may be affected by adjusting blood peroxide. The acute effect of poisoning illustrates itself with affecting on lung including Asthma and lung inflammation. The most significant function of cobalt in the human body is participation in the process of Vitamin $B_1$ production. On the other hand, the major impact of Cobalt is stimulating physiological actions.

Naturally, there is a small amount of cobalt in foodstuffs. Vitamin $B_{12}$ is one of the compounds that contain Cobalt so it is useful for human health. The maximum allowable concentration of Cobalt in air and water is 0.35 mg/m$^3$ and 0.10 mg/L, respectively and, 0.05 mg/L is the standard level for agricultural purposes and the maximum allowable in the soil would be 0.201 mg/m$^3$.

*Characteristics of Iron heavy metal*

Iron is a chemical element that rarely can be found in pure form in nature. The forms of this element compose around five percent of Earth's solid crust. The functions of Iron for organisms are fundamental and vital, for example, *Hemoglobin* and other enzymes containing Iron (Fe) collaborate in oxidation and transfer soluble gasses inside and outside of the cells**.** Major Iron (Fe) compounds are two forms that are $Fe^{++}$ and $Fe^{+++}$**.** The major function of Fe in the body includes oxygen transfer in the red blood cells, blood hemoglobin production, resistance to stress and illness, proper function of enzymes, and boosting the immunity system**.**

The destructive effects of Fe include necrosis hemorrhagic in the primary digestive system, obstruction of the intestines and, increase capillaries permeability cause decrease respiratory level with sedimentation (*Ferrous hydroxide*) on gills and also colonization make suffocation with covering eggs surface and preventing oxygen exchange.

*General characteristics of Mugliformes order*

They have two separate dorsal fins which are "Barbed fin" and the second one is "Barbed-soft ray fin". *Mugilidae* family is in this order that has coarse scales and circular, Flathead, Toothless, long gill-rakers to number 60-160, without or incomplete lateral line. In Golden mullet, length of snout and intestine is bigger than other species and has 140-150 number gill-rakers but the Maximum length is 52 centimeters and Maximum weight is 1900 grams and Maximum age is 9 years are general characteristics of Golden mullet that live in Caspian, Azov, and Black Seas.

*Scientific Classification*

Kingdom: *Animalia* Phylum: *Chordata* Class: *Actinopterygii*



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(Unranked): *Acanthomorpha* superorder: *Acanthopterygii* Clade: *Percomorpha* Unranked: *Ovalentaria* Order: *Mugiliformes* Family: *Mugilidae*

*Specific objectives and Hypothesis*

- Figure out the amount of heavy metals (Fe and Co) accumulation in the liver, muscle, and gill of *Chelon aurata* and, it is possible that the results can be different.
- Comparison of the values obtained from Fe and Co accumulation in the liver, muscle, and gills of golden mullet in coastal areas of the Caspian Sea and the results can be different in Mazandaran and Golestan provinces of Iran.

## Material and methods

*Sampling*

Samplings of adult fish (*Chelon aurata*) from 6 stations were performed on the coasts of Mazandaran and Golestan provinces. The six stations studied included four stations in Mazandaran province such as Tonekabon (Tonek.), Nowshahr (Nowsh.), Fereydunkenar (Ferryd.) and, Behshahr (Behsh.) and, two locations in Golestan province of Iran like Bandar Torkman (BTork.) and Gomishan (Gomi.). In total, 30 golden mullet fish were purchased live from 6 fishing companies. Samples were transferred to the freezing laboratory of Islamic Azad University, Tonekabon branch (Fig. 1).

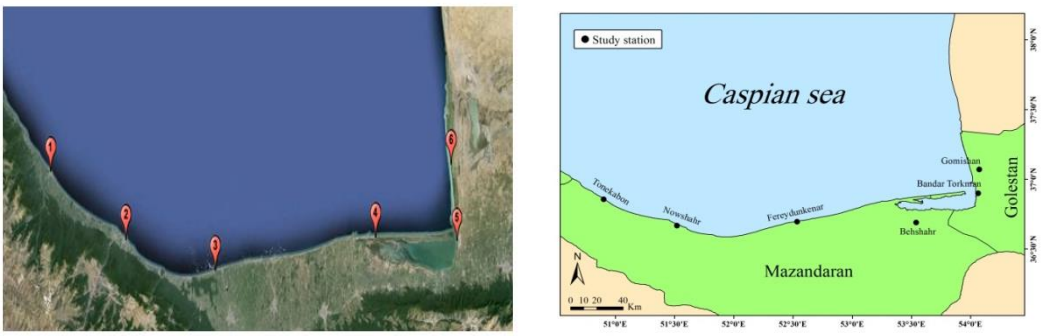


**Figure 1: Aerial, Lat & Long maps of study stations in Mazandaran and Golestan provinces.**

*Materials for digestion of tissues (liver, muscle and gill)*

In order to carry out laboratory work, laboratories equipment is required to be accurate and reliable so that laboratory work can be carried out according to the existing standard. Therefore, care should be taken in choosing materials and the quality of materials.

*The amount of required chemical materials*

The mentioned chemicals materials are for digestion of the liver, muscle, and gill tissue of each golden mullet fish which are studied according to the standard systems and in terms of the number of tissues and 3 replicates of the fish in each group, raises the amount of the chemical substrates (Table 1).



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**Table 1: The amount of chemicals for digestive tract (muscle, liver and gill) fish.**

| Type of Material | Required amount |
|---|---|
| Nitric Acid | 50 cc |
| Hydrogen Peroxide | 50 cc |
| Distilled water | Intake amount |

*Required equipment*

We needed some equipment consisting of the devices and laboratory equipment which are introduced in Table 2.

**Table 2: List of laboratory equipment that has been used for tissues digestion of muscle, liver, and gill.**

| Equipment |
|---|
| German AAS4 Zeiss atomic device |
| Digital Scale 0001/0 |
| Scalper a number + 10 bits |
| Pipette Graduated 20 ml |
| Balloon 1000 ml |
| Glass funnel |
| Whatman filter paper |
| Glass vial 10 ml |
| 5 cc syringe |
| Glue |

*Biometrics of the fish samples*

Samples were measured and recorded in a laboratory by Weighing-in and Measuring Board and Morphometric Traits Caliper in cm and gram (Fig. 2).

*Samples preparation*

First of all, fish samples were rinsed with water to remove surface and skin contamination. Subsequently, 10 grams of tissue (muscle, liver, and gill) of golden mullet were separated by the instrument (scalpel, scissors and pencil) and weighed by digital scales (Fig. 3).

**Figure 2: Overview of the morphometric characteristics of golden hulls.**

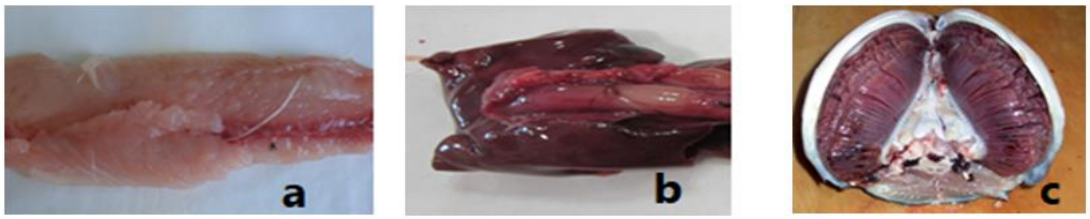


**Figure 3: The muscle (a), liver (b) and, gill (c) tissue of golden mullet.**

Each of the tissues; muscle, liver, and gills were placed in a balloon, then 50cc distilled water of $H_2O_2$ and 50cc of nitric acid were added. the prepared specimens that are inside the balloon to the clamp and place on a flame so that the sample is placed under gentle heat and after 2 to 2:30 hours, which arrived at a 5 ml dose, the heated sample was removed from the flame and diluted with 5cc distilled water into a volume of 10cc and then transferred to containers previously prepared for storage to be transferred to the atomic absorption laboratory (Fig. 4).



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**Figure 4: The preparation and digestion of tissues in the balloon.**

*Atomic absorption*

To measure heavy metal concentrations (cobalt and iron), the German AAS4 Zeiss was used for flame atomic absorption. First, the samples were filtered by the Whatman Filter No. 1 paper. The filtered solution was reached to a specific volume of 5 ml by deionized water, and the solution was stored in special polyethylene containers (Fig. 5).

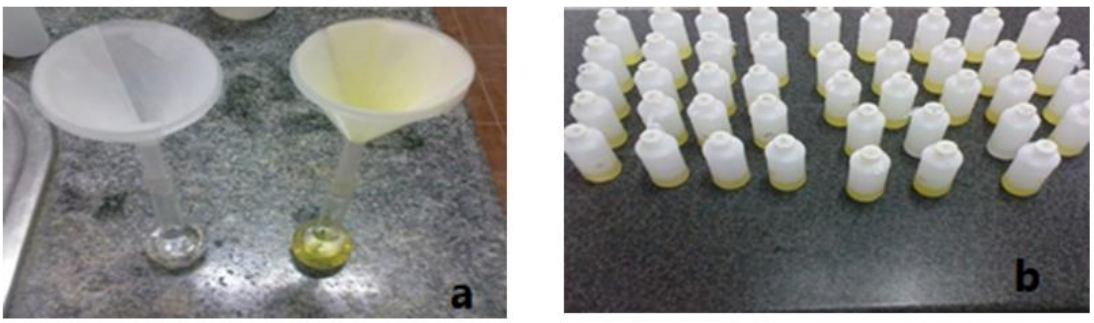


**Figure 5: The filtering of digested samples (a), placing digested samples in polyethylene containers (b).**

After the preparation of samples and standardization of samples, the concentration of heavy metals of cobalt and iron was measured by atomic absorption with a graphite furnace system (Fig. 6).

*Statistical analysis*

At the end of this study, data were expressed as mean±SD (N) and analysis was statistically performed by ANOVA and remarkable diversity was noted when probabilities were lower than 0.05.



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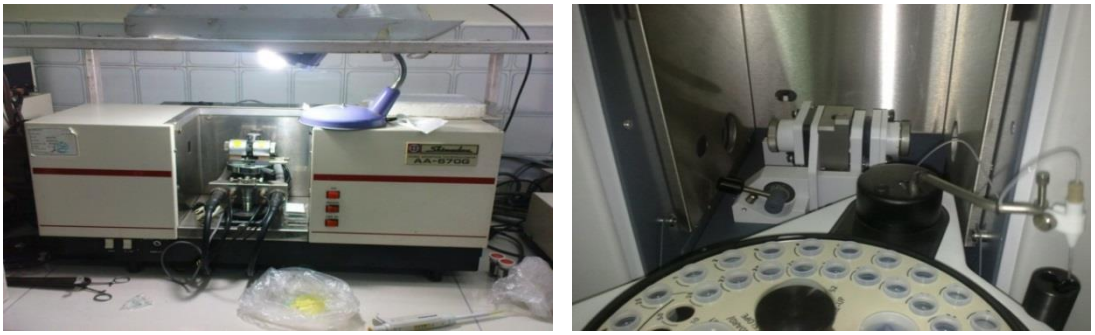

**Figure 6: A general view of the German AAS4 Zeiss atomic absorption.**

## Results

*Biological results of golden mullet in Mazandaran and Golestan provinces of Iran*

According to Tables 3 and 4, the results illustrated that in terms the weight of golden mullet between different stations in Mazandaran and Golestan provinces in the Iranian coastal of Caspian Sea was statistically significant ($p$<0.05), In general, the highest and lowest weight of the fish were in Behshahr in Gomishan, respectively. Tables 3 and 4 demonstrate these results about the weight of fish.

**Table 3: Descriptive statistics of the bodyweight (Weighted index) of golden mullet in Mazandaran and Golestan provinces.**

| Biological Indicators | Station | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| **Body Weight BW (g)** | Tonekabon | 1272$^{ab}$ | 337 | 884 | 1474 |
| | Nowshahr | 1170$^{ab}$ | 74 | 986 | 1118 |
| | Fereydunkenar | 854$^{bc}$ | 22 | 840 | 880 |
| | Behshahr | 1305$^{a}$ | 389 | 1074 | 1754 |
| | Bandar Torkaman | 830$^{abc}$ | 254 | 540 | 1010 |
| | Gomishan | 608$^{b}$ | 79 | 518 | 658 |

**Table 4: Descriptive statistics of heavy metal of iron (mg/kg.ww) in grey mullet fish.**

| Tissue | Station | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| Muscle | Tonekabon | 3.79$^{b}$ | 0.25 | 3.5 | 3.97 |
| | Nowshahr | 4.07$^{abc}$ | 0.06 | 4 | 4.11 |
| | Fereydunkenar | 4.15$^{abc}$ | 0.14 | 4 | 4.27 |
| | Behshahr | 4.25$^{abc}$ | 0.13 | 4.15 | 4.40 |
| | Bandar Torkaman | 4.03$^{ab}$ | 0.04 | 4 | 4.08 |
| | Gomishan | 4.01$^{ab}$ | 0.01 | 4 | 4.02 |
| Liver | Tonekabon | 15.85$^{d}$ | 0.06 | 15.8 | 15.92 |
| | Nowshahr | 15.96$^{c}$ | 0.05 | 15.9 | 16 |
| | Fereydunkenar | 16.05$^{c}$ | 0.04 | 16.01 | 19.06 |
| | Behshahr | 16.17$^{b}$ | 0.06 | 06.10 | 16.23 |
| | Bandar Torkaman | 16.03$^{c}$ | 0.41 | 16 | 16.08 |
| | Gomishan | 16.32$^{a}$ | 0.03 | 16.30 | 16.36 |
| Gill | Tonekabon | 14.38a | 0.34 | 14 | 14.66 |
| | Nowshahr | 14.21$^{a}$ | 0.18 | 14 | 14.35 |
| | Fereydunkenar | 13.42$^{b}$ | 0.37 | 13 | 13.68 |
| | Behshahr | 14.42$^{a}$ | 0.36 | 14 | 14.66 |
| | Bandar Torkaman | 14.36$^{a}$ | 0.31 | 14 | 14.59 |
| | Gomishan | 14.34$^{a}$ | 0.21 | 14 | 14.52 |



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*Results of the accumulation of heavy metals of iron and cobalt in golden mullet in the regions of Mazandaran and Golestan provinces (Caspian Sea)*

*Results of the accumulation of heavy metal in the golden mullet fish*

According to Tables (5) and (6), the results of ANOVA showed that iron adsorption in muscle tissue had the highest amount in the Behshahr region 4.25 mg/kg.ww and the lowest amount in the Tonekabon region was 3.79 mg/kg.ww which this difference was statistically significant ($p$<0.05; Fig. 7).

**Table 5: ANOVA test results; heavy metal iron accumulation in golden mullet.**

| Indicators | SS | DF | MS | MST/MSE | Significance Level |
|---|---|---|---|---|---|
| Muscle | 0.363 | 5 | 0.073 | 4.080 | 0.021 |
| Liver | 0.408 | 5 | 0.082 | 31.419 | 0.000 |
| Gills | 2.182 | 5 | 0.436 | 4.566 | 0.015 |

**Table 6: ANOVA test results, Cobalt heavy metal accumulation in *Chelon aurata*.**

| Indicators | SS | DF | MS | MST/MSE | Significance Level |
|---|---|---|---|---|---|
| Muscle | 0.051 | 5 | 0.010 | 249.703 | 0.00 |
| Liver | 0.002 | 5 | 0.000 | 5.956 | 0.005 |
| Gill | 0.002 | 5 | 0.000 | 3.182 | 0.047 |

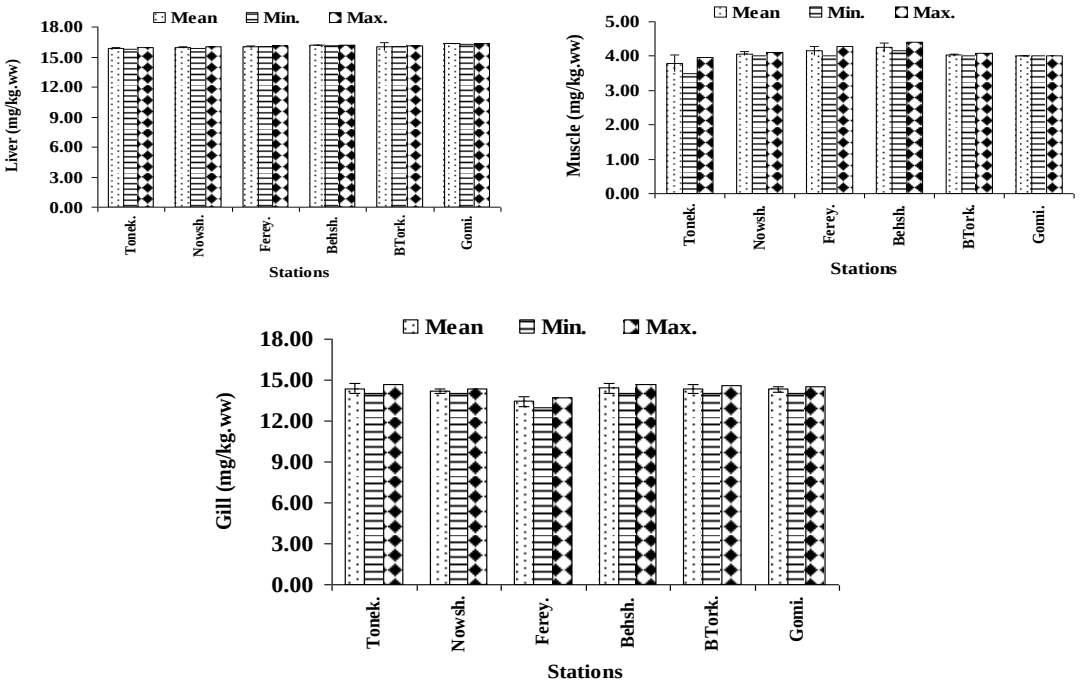


**Figure 7: Iron accumulation (mg/kg.ww) in muscle, liver and gill tissue of golden mullet.**

The absorption rate of the liver was highest in the Gomishan area 16.26 mg/kg.ww and the lowest in the Tonekabon region was 15.85 mg/kg.ww. This difference was statistically significant ($p$<0.05; Fig. 8). Also, the ANOVA comparisons demonstrated that the highest gill absorption rate was in the Behshahr



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region (42.24 mg/kg.ww) and the lowest in the Fereydunkenar region (13.42 mg/kg.ww), and this difference was statistically different ($p$<0.05).

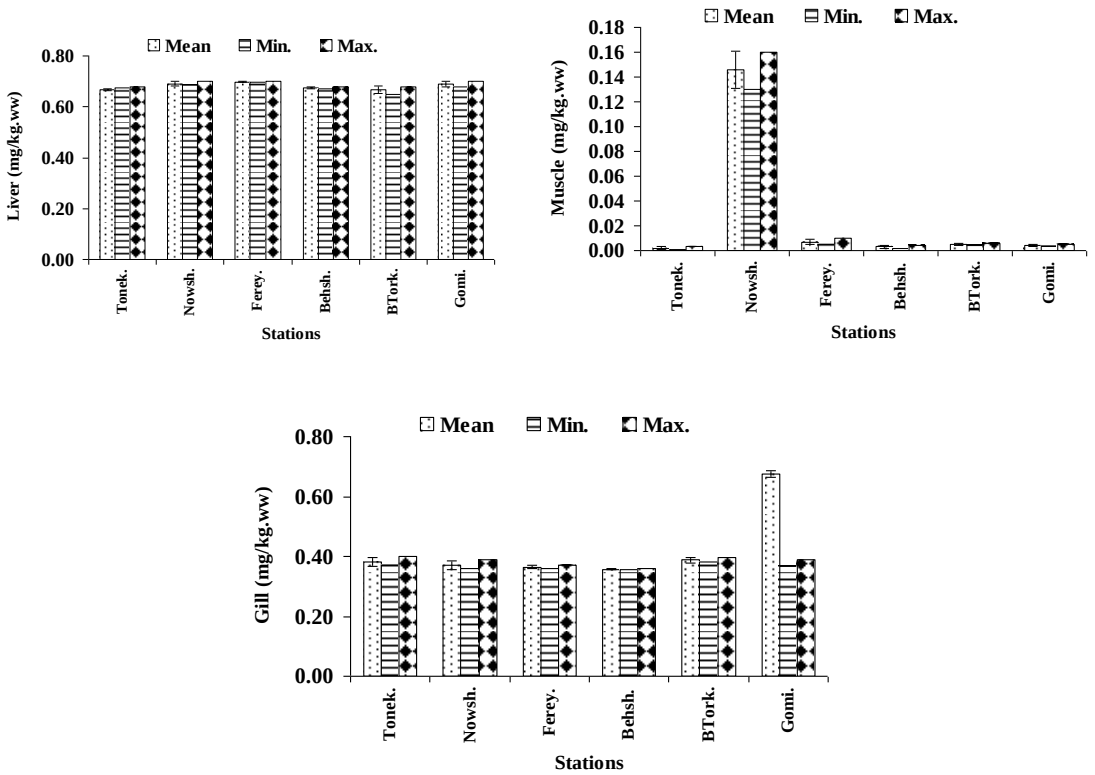


**Figure 8: Cobalt accumulation (mg/kg.ww) in muscle, liver and gill tissue of golden mullet.**

*Results of the accumulation of heavy metal cobalt in golden mullets*

According to Tables 6 and 7, the results of ANOVA illustrated that the adsorption rate of cobalt heavy metal in muscle tissue was the highest in the Nowshahr region (0.146 mg/kg.ww) and, the lowest in the Tonkabon region was 0.002 mg/kg.ww and this difference was statistically significant ($p$<0.05). Fig. 8 shows the absorption rate in the liver tissue was highest in the Behshahr region (0.975 mg/kg.ww) and lowest in Bandar Turkman (0.666 mg/kg.ww). This difference was statistically significant ($p$<0.05). And the rate of absorption in gill tissue was the highest in Bandar Turkman (0.38 mg/kg.ww) and the lowest in the Fereydunkenar region was 372.0 mg/kg.ww, and this difference was statistically significant ($p$<0.05).

**Table 6: ANOVA test results, Cobalt heavy metal accumulation in *Chelon aurata*.**

| Indicators | SS | DF | MS | MST/MSE | Significance Level |
|---|---|---|---|---|---|
| Muscle | 0.051 | 5 | 0.010 | 249.703 | 0.00 |
| Liver | 0.002 | 5 | 0.000 | 5.956 | 0.005 |
| Gill | 0.002 | 5 | 0.000 | 3.182 | 0.047 |



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**Table 7: Descriptive statistics of heavy metal of cobalt (mg/kg.ww).**

| | Station | Mean | SD | Min. | Max. |
|---|---|---|---|---|---|
| **Muscle** | Tonekabon | 0.002[b] | 0.001 | 0.001 | 0.003 |
| | Nowshahr | 0.146[a] | 0.015 | 0.130 | 0.160 |
| | Fereydunkenar | 0.007[b] | 0.002 | 0.005 | 0.010 |
| | Behshahr | 0.003[b] | 0.001 | 0.002 | 0.004 |
| | Bandar Torkaman | 0.005[b] | 0.001 | 0.004 | 0.006 |
| | Gomishan | 0.004[b] | 0.001 | 0.003 | 0.005 |
| **Liver** | Tonekabon | 0.677[bc] | 0.003 | 0.674 | 0.680 |
| | Nowshahr | 0.691[ab] | 0.008 | 0.684 | 0.7 |
| | Fereydunkenar | 0.698[a] | 0.002 | 0.697 | 0.701 |
| | Behshahr | 0.975[bc] | 0.004 | 0.671 | 0.680 |
| | Bandar Torkaman | 0.666[c] | 0.015 | 0.650 | 0.680 |
| | Gomishan | 0.690[ab] | 0.010 | 0.680 | 0.7 |
| **Gill** | Tonekabon | 0.383[ab] | 0.015 | 0.369 | 0.4 |
| | Nowshahr | 0.372[abc] | 0.015 | 0.361 | 0.390 |
| | Fereydunkenar | 0.364[bc] | 0.005 | 0.360 | 0.37 |
| | Behshahr | 0.357[c] | 0.002 | 0.355 | 0.36 |
| | Bandar Torkaman | 0.388[a] | 0.009 | 0.380 | 0.398 |
| | Gomishan | 0.376[abc] | 0.012 | 0.368 | 0.39 |

*Results of the comparison of heavy metals accumulation between the three muscle, liver and, gills of golden mullet*

*Results of the comparison of heavy metal iron accumulation between three muscle tissue, liver and grey mullet*

According to Tables 8 and 9, the results of ANOVA showed that the heavy metal iron accumulation in muscle tissue was 4.05 mg/kg, in liver tissue is 16.05 mg/kg and in gills is 14 mg/kg which was the highest absorption in liver tissue and the lowest absorption in muscle tissue, and this difference was statistically different with probability less than 0.05 (Fig. 9).

**Table 8: Mean and standard deviation of iron heavy metal (mg/kg) in golden mullet, muscle, liver, and gills.**

| Tissue | Mean | SD | Min. | Max. |
|---|---|---|---|---|
| Muscle | 4.05[c] | 0.18 | 3.5 | 4.4 |
| Liver | 16.05[a] | 0.15 | 15.8 | 16.36 |
| Gill | 14.3[b] | 0.67 | 13 | 16.3 |

**Table 9: ANOVA test results of heavy metal iron (mg/kg) accumulation in golden mullet, muscle, liver, and gills.**

| SS | DF | MS | MST/MSE | Significance Level |
|---|---|---|---|---|
| 1500.114 | 2 | 750.057 | 4501.859 | 0.000 |

*Comparison results of heavy metal, cobalt accumulation between three tissues, muscle, liver, and gill of golden mullet*

The results of Tables 10 and 11 show that the accumulation of heavy metal of cobalt in the muscle tissue was (0.28 mg/kg), in the liver tissue (0.68 mg/kg) and in the gill (0.38 mg/kg), which had the highest absorption in liver tissue and the lowest absorption in muscle



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tissue, and this difference was statistically different ($p$>0.05; Fig. 10).

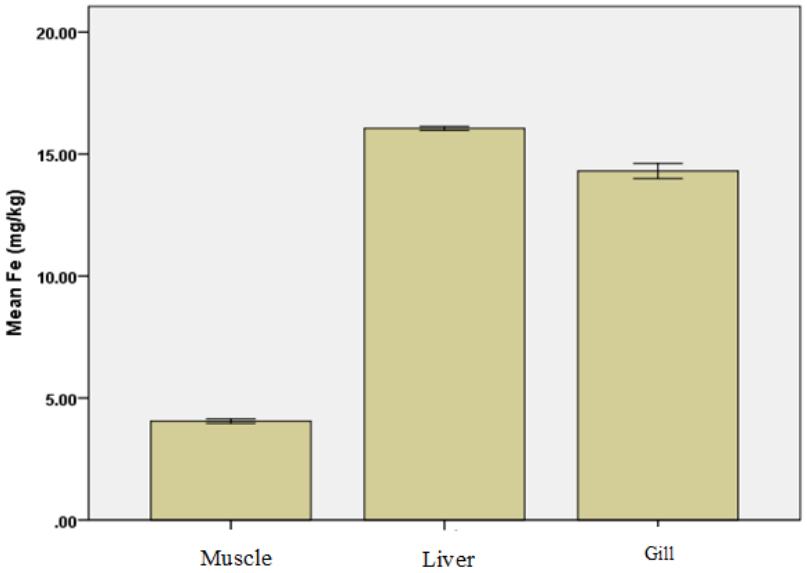


**Figure 9: The column chart Iron absorption (mg/kg.ww) in the muscle, liver and, gills.**

**Table 10: Average and standard deviation of heavy metal cobalt (mg/kg) in muscle, liver, and gill of golden mullet.**

| Tissue | Mean | SD | Min. | Max. |
|---|---|---|---|---|
| Muscle | 0.28[c] | 0.054 | 0.001 | 0.160 |
| Liver | 0.68[a] | 0.013 | 0.65 | 0.70 |
| Gill | 0.38[b] | 0.71 | 0.35 | 0.68 |

**Table 11: ANOVA test results of heavy metal cobalt (mg / kg) in muscle, liver, and gill of golden mullet.**

| SS | DF | MS | MST/MSE | Significance Level |
|---|---|---|---|---|
| 3.779 | 2 | 1.889 | 656.883 | 0.000 |

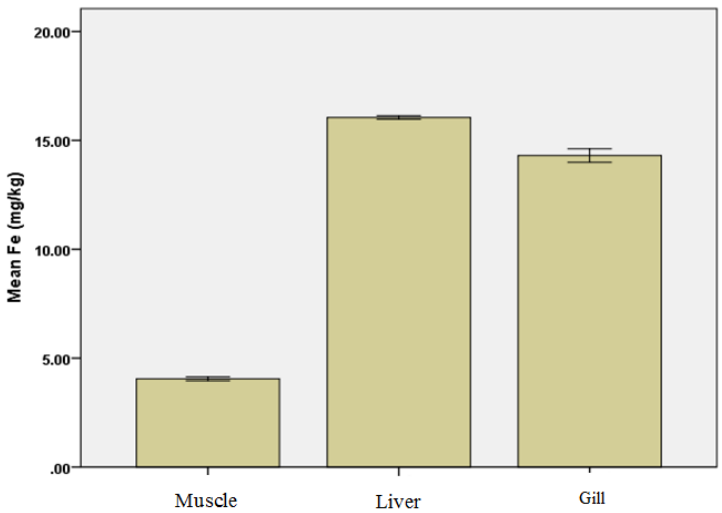


**Figure 10: The column chart of Cobalt heavy metal adsorption (mg/kg.ww) in the muscle, liver and, gill of golden mullet.**



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**Discussion**

The results of this research on the golden mullet fish biometry in 6 stations of Tonekabon, Nowshahr, Fereydunkenar, and Behshahr in Mazandaran province and Bandar Torkaman and Gomishan stations in Golestan province of the coastal Caspian sea of Iran showed that the average weight of the highest belonged to Behshahr samples with 1305 g and the lowest recorded weight was related to Gomishan area with 608 grams and this difference was statistically different with probability less than 0.05 ($p$<0.05). The results of total length, standard and, fork indicators also showed an average of 63.66 cm and the lowest total length recorded in Gomishan coastal area fish that was 46.03 cm, and this difference was statistically significant ($p$<0.05) and the standard length in the Behshahr coastal district fish was 47.06 and the lowest standard recorded for the Bandar Turkaman was 39.33 cm, but this discrepancy was not significant ($p$<0.05).

In terms of the highest fork length in the Behshahr fish was 52.13 cm and the minimum fork length was recorded for Gomishan fish with 44.60 cm, and this difference was statistically significant ($p$<0.05). According to studies, golden mullet is at the time of sexual rest in the spring and is at the time of sexual maturity in the fall and reproduces near the beach (Yilmaz *et al*., 2007). In the autumn season, the time of sexual maturity, the ovaries of these kinds of species are full of sexual cells, e.g. oocytes and spermatozoids, which is why the weight of the fish is higher than in normal situations. Also, the high biometric indices in the Behshahr coastal golden mullet can be explained by the fact that the mullet fish are tolerant to the temperature of the environment. But it has a great sensitivity to reducing the water temperature and moves from the point of lowering the temperature to the warmer water. The mullet is one of the Euaryhaline fish, and we can often find this fish in 30 ppt salinity or less than 30 ppt (Canli and Atli, 2003).

According to the recorded data in the coastal of the Behshahr station, the temperature and salinity levels in the physiological range of this fish were due to the favorable environmental and biological conditions of fish growth and the amount of chemical composition of fish in this region is higher than the Gomishan station.

In order to evaluate the adsorption of heavy metal, iron and, cobalt in three parts of golden mullet (muscle, liver, and gill) was calculated from the atomic device in mg/kg.ww. The results showed that iron adsorption in muscle tissue was highest in Behshahr coastal fish with 4.25 mg/kg.ww and the lowest in Tonekabon region fish with 3.79 mg/kg.ww so that this difference was statistically significant ($p$<0.05). The absorption rate of heavy metal of liver tissue in different regions was different and the highest amount in the Gomishan area fish was 16.26 mg/kg.ww and the lowest in Tonekabon coastal fish was 15.85 mg/kg.ww so this discrepancy was statistically



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significant ($p$<0.05). The amounts of these heavy metals (Fe and Co) in gill tissue were varied in different stations and the highest amount in the Behshahr region was 14.42 mg/kg and the lowest one in Fereydunkenar region was 13.42 mg/kg.ww, and this difference was statistically significant with probability less than 0.05.

The Iron acts as an oxygen carrier from the lungs into the tissues, and hemoglobin, red blood cells, as a medium for transporting electrons in the cell, and as an integral part of important enzyme systems in various tissues (Sardashti, 2007; Yilmaz *et al*., 2007). The study of the accumulation of heavy metals in the fish body of *Capoeta umbla* and its relation with age, weight, and sex stated that the concentration of heavy metal iron is 87.21 mg/kg (Mohamed *et al*., 2010). Also, the study results of heavy metal accumulation in 5 commercial species in Sudan reported that the iron absorption was 26 mg/kg *Lates niloticus*, 17 mg/kg *Bagrus bayad*, 26 mg/kg *Oreochromis nilotius*, respectively. *Syonodontis schall* with 60 mg/kg and *Tertaodon lineatus* with 61 mg/kg were similar to the results of the present study.

Fish is the most important source of iron for children and adults, and the deficiency of this element causes anemia. Iron performs a major role in the building of red blood cells, making it an important component of hemoglobin, and its deficiency in fish causes the complication of the name of anemia called Hypochromic Microcytic, however high levels of iron may lead to unpleasant results like hemochromatosis (Mohamed *et al*., 2010). The daily intake of iron in the normal diet of developed countries is estimated to be about 15 to 22 milligrams per day.

The results of the current study showed that the accumulation of cobalt heavy metal in muscle, liver, and gills tissues was 0.28, 0.68, and 0.38 mg/kg.ww, respectively so that they had the highest absorption in the liver tissue and lowest absorption in the muscle tissue and the difference was statistically significant ($p$<0.05). The information of study on the cobalt density in *Rutilus Kutum* and *Cyprinus Carpio* in the Caspian Sea illustrated that its content in *Rutilus Kutum* was 0.30 µg/g dry weight and in carp was 1.08 µg/g. The dry weight of the sample was declared higher than the limitation of fish muscle (0.2 µg/g dry weight) (Belitz *et al*., 2001).

The study results on the Neil tilapia (*Oreochromis niloticus*), northern Mediterranean Sea fish, catfish of the Atatürk Lake in Turkey, whitefish and the pompous fishes (Friedrich and Stepanowska, 1999; Mohamed *et al*., 2010). The results of this study are based on the lowest absorption and concentration of heavy metals in the muscle. Since water is the foundation of all organisms and ecosystems, protecting marine resources is an important part of maintaining all ecosystems. Undoubtedly, if environmental subjects and concerns are not taken into account and uncontrolled use of insecticides,



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fungicides, chemical fertilizers and the lack of proper treatment of urban and industrial wastewater will be severely damaged in the near future and the ecosystem of the Caspian Sea will be severely and definitely damaged, therefore eliminating these problems requires effective management of coastal areas, fishing, collecting, purifying and disposing of pollutants from seawater and improving the indicators. Additionally, providing outcomes to relevant organizations to maintain and enhance the health and sustainable development of the community, will prevent some diseases and provide an introduction to future research.

## Conclusion

The present study was carried out in golden mullet on different tissues including muscle, liver and, gills in the coastal Caspian Sea of two Iranian provinces (Mazandaran and Golestan provinces).

The results of this study on the golden mullet biostratigraphy in 6 stations of Mazandaran province with four locations (Tonekabon, Nowshahe, Fereydunkenar, and Behshahr) and Golestan province with two locations (Bandar Torkaman and Gomishan) on the average body weight, total length, and fork length showed that Behshahr and Gomishan coastal golden mullet had highest and lowest recorded weight so that difference in ABW was significant in terms of the journal ($p$<0.05). The amounts of iron and cobalt heavy metals accumulation were highest in Behshahr region fish and its difference with other stations was statistically significant ($p$<0.05). In general, it can be stated that iron accumulation in the liver and the gill tissues in Golestan province were higher than in Mazandaran province. Regarding the accumulation of heavy metal of cobalt in the liver, gill and, muscle tissues in Mazandaran province, it was more than Golestan province. The iron and cobalt accumulations were the highest in the liver, gill, and muscle tissues, respectively (liver> gill> muscle). In the end, the census of heavy metals iron and cobalt at present research in three tissues; muscle, liver, and gill of golden mullet in two provinces of Iran showed that they are less than the announced standard levels (SL) of the World Health Organization (WHO), United Nation (UN), Food and Agriculture Organization (FAO), and the United States Department of Agriculture (USDA) and the consumption of this kind of fish under that environment and condition (coastal areas of Mazandaran and Golestan provinces) are noxious for human consumption.

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